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US Army Corps of Engineers
Waterways Experiment Station

Hydroacoustic Evaluations of Juvenile Salmonid Passage at Bonneville Dam Including Surface-Collection Simulations

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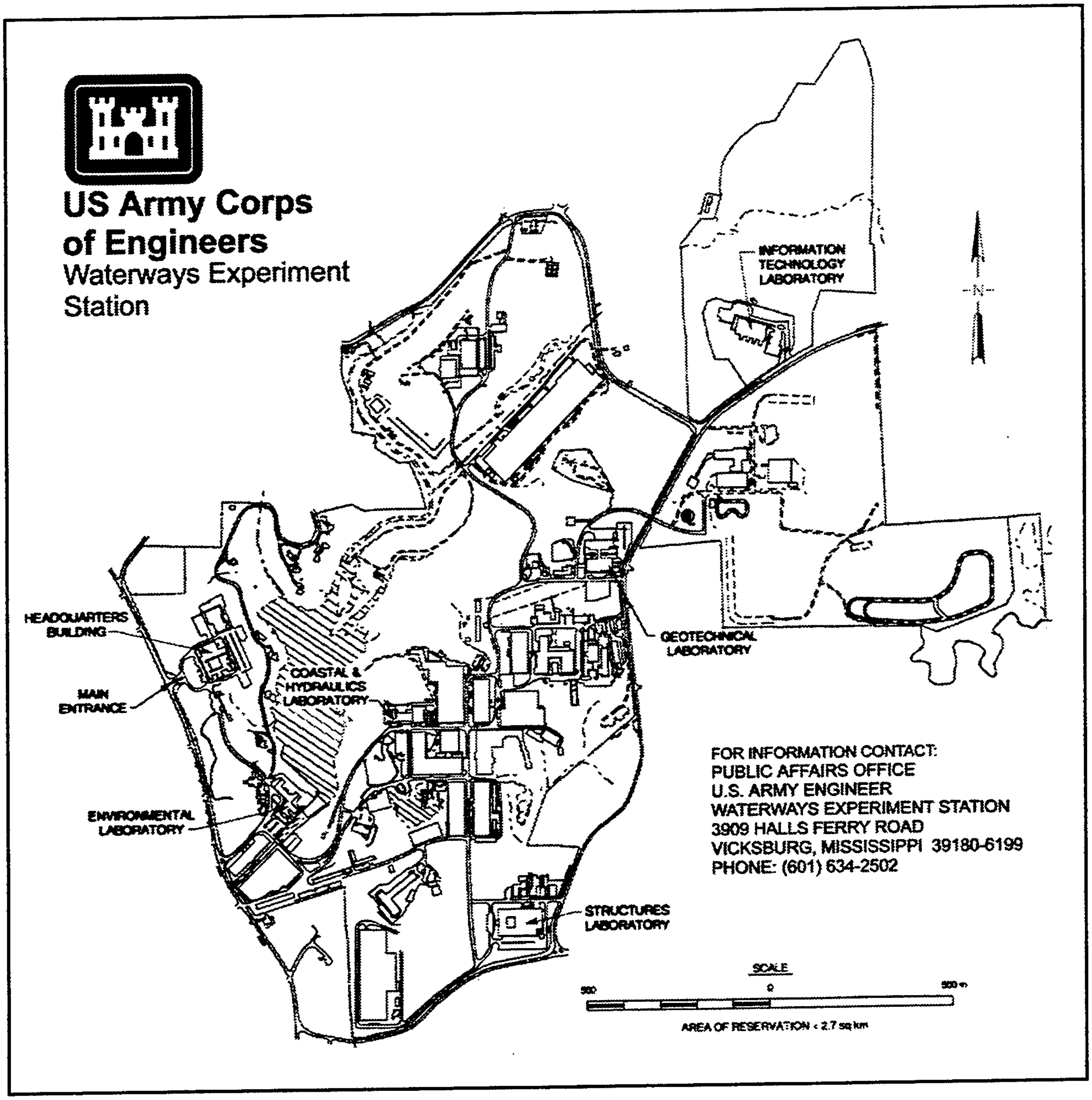

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Preface

The report herein was prepared for the U.S. Army Engineer District, Portland, by the Fisheries Engineering Team (FET), Water Quality and Contaminant Modeling Branch (WQCMB), Environmental Processes and Effects Division (EPED), Environmental Laboratory (EL), U.S. Army Engineer Waterways Experiment Station (WES), with support from AScI Corporation, Mclean, VA, DynTel Corporation, Vicksburg, MS, and the U.S. Army Engineer District, Portland, Fishery Field Unit (FFU) and Environmental Resources Branch (ERB). The report was prepared by Messrs. Gene R. Ploskey, FET, Peter N. Johnson, AScI, William T. Nagy, FFU, Mike G. Burczynski, DynTel, and Dr. Larry R. Lawrence, FET, and was conducted under the general supervision of Dr. Mark S. Dortch, Chief, WQCMB; Dr. Richard E. Price, Chief, EPED; and Dr. John Harrison, Director, EL.

Many other people made valuable contributions to this study. Mr. Marvin Shutters, ERB, helped man a safety boat for mobile acoustic surveys, and Mr. Larry Beck and Ms. Sally Jones, FFU, assisted when Mr. Shutters was unavailable. Many people helped process data from underwater video cameras including Messrs. Johnson, Burczynski, Scott Bourne, Bruce Sabol, Mike Cariola, and Buddy Sanders and Ms. Elizabeth Lord. Visual tracking of fixed-aspect hydroacoustic data was done by Mr. Burczynski and Mses. Ellen Czaika, Hope Waite, Anila Taylor, and Linda Moss. Ms. Virginia Sutton and Mr. Nagy spent months developing automated fish-tracking algorithms and computer programs. Mr. Gary Weeks and Ms. Deborah Patterson helped process data and create figures. Mr. Rick Martinson, National Marine Fisheries Service, provided 1996 juvenile bypass data. Riggers from the Bonneville Project moved trash racks with a gantry crane and welded shackles and conduits for cable routing during transducer installations at both powerhouses, moved trash racks to facilitate repair of acoustic equipment, and shuffled 9 blocked and 18 unblocked trash racks weekly at Powerhouse 1 to create test treatments. Bonneville rigging crews also provided a crane and man basket to help the WES team install acoustic monitoring equipment at the sluice chute at Powerhouse 2. Mr. Vincent Schlosser provided welding support for attachment of conduits to trash racks when Project riggers were not available.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
feet	0.3048	meters

Summary

This Technical Report describes results of studies conducted by the US Army Engineer District, Portland (CENPP) and the US Army Engineer Waterways Experiment Station (CEWES) to resolve critical uncertainties in the implementation of smolt-collector technologies and estimation of fish passage efficiency (FPE) for the Bonneville Project. Available biological information is inadequate to design and locate surface collector prototypes at Bonneville Dam (Giorgi and Stevenson 1995). Information on the vertical and lateral distributions of smolts in forebay areas of both powerhouses and the spillway was limited, no mobile surveys had been conducted, and no manipulative testing had been done to determine likely responses of smolts to surface openings.

The goals of this study were to (1) provide biological information necessary to facilitate the design and placement of a surface-collector prototype and (2) make progress toward the estimation of FPE for the entire Bonneville Project. Objectives were to:

1. use mobile hydroacoustics to measure the vertical and horizontal distribution of salmon smolts in forebay areas of both powerhouses and to characterize the day and night variation in distributions in spring and summer;
2. estimate smolt passage into two turbines and into the center sluice gate above each turbine, as well as the FPE ratio for paired sluiceway/turbine openings under two test conditions (blocked versus unblocked trash racks and open versus closed sluice gates) in spring and summer at Powerhouse 1;
3. evaluate smolt swimming direction in the area immediately upstream of two test units at Powerhouse 1, particularly at the zone of separation between flows entering turbines and flows entering sluice gates.
4. estimate guided and unguided smolt passage into eight turbine intakes of Powerhouse 2 and identify effects of an open or closed sluice chute on the fish guidance efficiency (FGE) of adjacent turbine units;

Mobile surveys showed that there were significant longitudinal, lateral, and vertical gradients in smolt density that provide opportunities in optimizing surface collector prototype location and configuration. At Powerhouse 1, mean densities generally were higher in mid-channel areas in spring and were more spread out along the powerhouse face in summer. If this pattern is consistent in 1997 mobile surveys, a good test location for a prototype collector would be near the center of the powerhouse at units 3-5 or 4-6, especially in spring. Lateral densities at Powerhouse 1 in summer suggest that many young-of-year smolts would encounter a centrally located collector, although the highest densities of sub-yearling smolts may be shore oriented. We found a consistent upward shift in the vertical distribution of smolts at transects within 20 m of Powerhouse 1 relative to transects 50-75 m upstream. This shift may be explained by smolts moving up in the water column as they approach the dam, a behavior that a surface collector could exploit. In contrast, we found a downward shift in the vertical distribution of smolts at transects within

30 m of Powerhouse 2 relative to transects located 50-75 m upstream. This downward shift probably is a function of hydrology and rapid increases in depth as smolts approach Powerhouse 2. Lateral distributions of smolts were more consistent for both seasons at Powerhouse 2 than at Powerhouse 1 and, if confirmed by 1997 mobile surveys, we would recommend intakes 11-13 or Unit 18 as good locations for a collector prototype because that is where we usually observed the highest densities of smolts. With modification, the sluice chute near unit 11 also would be a good collector because of its proximity to relatively high densities of smolts holding upstream of Unit 11-13. We usually found lower densities upstream of Unit 11-13 on days when the sluice chute was open than when it was closed suggesting that the chute reduced smolt delays in the south eddy. However, we found no effect of sluice-chute operations on the fish-guidance efficiency of traveling screens in adjacent intakes. Therefore, benefits of the sluice chute would appear to be solely a function of numbers of smolts it passed. Previous research has suggested that a 1/4 gate opening on the sluice chute could pass 25-50% of the numbers passed at a single turbine. We tried several times to sample the sluice chute with fixed-aspect hydroacoustics and found high background noise from entrained air that obscured smolts smaller than about -47 dB or about 100 mm long from reliable detection. Also, surges in turbulent flow moving around the TIE at 11A prevented reliable counting of larger smolts one fourth of the time. We did not continue acoustic sampling of the chute because we doubted that estimates would be accurate given noise that frequently would obscure smolts from detection and the high probability of mistakenly counting bubbles as fish.

Results from 1996 sampling of smolt passage at Powerhouse 1 with fixed-aspect hydroacoustics and underwater video cameras provided promising evidence that surface collection could substantially increase FPE at Bonneville Dam. The 1996 results were not without ambiguities, many of which can be explained by high variation in smolt counts among days and significant differences among test units and intakes that kept us from pooling data to increase sample size and the power of statistical tests.

Several response variables were created to analyze effects of test treatments or locations. We standardized two passage variables to minimize effects of migration timing that might obscure treatment effects which were assigned by day or week. Standardized turbine passage (STP) was the total number of smolts passing into a test turbine per treatment day divided by the number of smolts estimated to have passed through the juvenile bypass during the same time period. Similarly, standardized sluice passage (SSP) was the total number of smolts passing into a center sluice opening per treatment day divided by the number of smolts estimated to have passed through the juvenile bypass during the same time period. Other variables expressed the number of smolts passing by a specific route at a turbine unit to the number passing by all available routes at the same unit. These efficiency variables reflect the relative importance of one route to other routes being considered. For example, fish guidance efficiency (FGE) was the percent of all in-turbine smolts that were guided by traveling screens. Fish passage efficiency (FPE) was the percent of all smolts (screen guided, unguided, and sluice passed) that passed by non-turbine routes (i.e., guided and sluice passed). Sluice passage efficiency (SPE) was the percent of all smolts (guided, unguided, and sluice passed) at a turbine unit that passed through the center sluice gate.

We found considerable evidence that blocking trash racks (lowering the zone of flow separation) was beneficial. For example, standardized turbine passage (STP) was significantly less for blocked treatments (passage under blocks) than for unblocked treatments at Unit 3 in spring (53% less) and summer (70.3% less). In spring, for example, intakes 3A, 3C, and 5A all had lower mean STP when racks were blocked than when they were unblocked. In summer, intakes 3A, 3C, and 5B all had lower mean STP when racks were blocked than when they were unblocked, and the differences at intake 3B was nearly significant (P=0.0553). Standardized sluice passage and sluice passage efficiency (SPE) did not

differ significantly between blocked and unblocked treatments probably because tests lacked sufficient power to reject the null hypothesis of no difference. The mean ratio of blocked to unblocked mean sluice passage was 6.8 for Unit 3 and 2.2 for Unit 5, and differences were nearly significant at the 5B sluice in spring ($P = 0.0809$). Non-significant increases in SPE during blocked trash-rack treatments were + 14.6 % for Unit 3 and + 12.8 % for Unit 5. The behavior of smolts upstream of trash racks also was informative. At intake 3B and depths of 5-6 m, the mean number of smolt-sized fish moving up in the water column and the ratio of upward- to downward-moving fish were both significantly higher for blocked than for unblocked treatments. At intake 5B, significantly more fish were moving up and down in the water column when trash racks were blocked than when they were unblocked. This milling of smolts upstream of the block cannot occur during unblocked treatments because of flow into the intake. Milling may afford smolts time to discover the surface opening, but it also may make them more vulnerable to predation. In contrast to spring results, sluice passage efficiency at Unit 5 was significantly lower when racks were blocked than when they were not blocked in summer. Apparent differences in effects of trash-rack blocks on sluice passage and SPE in spring and summer may result from differences in swimming ability of yearling and sub-yearlings smolts.

We could not estimate FGE or FPE for blocked-trash-rack treatments and make meaningful comparisons to unblocked treatments because traveling screens were present in one treatment but not the other. Even if screens had been deployed behind trash rack blocks, there was insufficient flow to guide smolts. Fish behind trash-rack blocks were moving slowly in and out of the up-looking acoustic beam and differences in counts for blocked and unblocked treatments likely resulted from multiple counts of milling fish in low velocity flows behind blocks. Consequently, we did not use counts of fish behind blocks to evaluate treatments.

Underwater cameras showed that the lateral distribution of smolts passing into sluice 5B was consistently skewed (two to one) toward the sides of the gate near concrete piers. The skewed distribution was observed both night and day and in spring and summer and has important implications for sampling smolt passage at these sluice openings. For example, acoustic sampling with a single up-looking transducer would underestimate passage by 50%. Adequate sampling would require more up-looking transducers to sample the lateral distribution, or the orientation of a single transducer would need to be changed from vertical to horizontal to integrate counts across the opening.

Provision of a surface opening at sluice gates significantly increased non-turbine smolt passage, although the effect of a 0.5-2 m deep opening on more deeply distributed smolts appeared to be limited. Opening a center sluice gate significantly increased the mean FPE of Unit 5 by 35.5 % (from 27.5 to 63.0 %) in spring and at Unit 3 by 46 % (from 30.3 to 76.9 %) in summer. For Unit 3 in spring and Unit 5 in summer, respective FPE means of 58.6 and 39.1 % for the open sluice treatment were 18.6 and 10.1 % higher than means for the closed sluice treatments (40 and 29 %, respectively), although differences were not significant at $\alpha = 0.05$. In-turbine FGE relative to traveling screens was not significantly affected by opening or closing the sluice gate of either unit in spring or summer. We found no significant effect of sluice-gate treatments on vertical movements of smolts, a finding suggesting that open-sluice treatments have a limited range of influence for attracting juvenile salmonids. Flow vectors 6 m upstream of a sluice gate opened 2 m were downward into the intake at depths > 2 m when trash racks were not blocked and downward at depths > 4.0 m when trash racks were blocked. No attraction flow would be discernable at greater depths for the respective treatments.

We found significant differences in total smolt passage among seasons, time of day, and intakes at Powerhouse 2. Smolt passage was higher in summer than in spring, at night than during the day, at Unit 11 than at other intakes in spring, and apparently at units on the south end of the powerhouse (11-14) than at units on the north end in summer. We found a very close correspondence between spring run timing estimated by acoustic samples and trap catches in the bypass. Correspondence also was good in summer after we excluded high passage rates from units 11-14 during the first week of summer from Powerhouse 2 averages. Numbers were inflated at the southern intakes during the first week of summer immediately after river flows peaked for the year and loaded the south eddy with debris. The diel trend in total smolt passage was similar to the trend in juvenile bypass numbers in spring and summer, although it was highly variable among days. Sluice-chute treatments had no effect on standardized turbine passage at any intake in spring or summer.

Tests on mean FGE at Powerhouse 2 revealed significant differences among seasons, time of day, and intakes, but FGE was not affected by sluice-chute treatment. Estimates of FGE were higher in spring than summer and during the day than at night. Mean FGE of individual intakes ranged from about 16 to 66 % in spring and from 10 to 42 % in summer. Sluice chute treatments had no effect on FGE in spring or summer. Average FGE declined during summer from about 55 to about 30 %. Vertical distribution data from mobile surveys suggested that FGE should be 20 % higher in spring than what was measured in-turbine with fixed-aspect transducers and 32 % higher in summer, at least during the day. Either the distribution of smolts changed within 10 m of the structures where we did not sample or smolts were avoiding screens as they entered intakes. Both hypotheses are testable.

The 1996 acoustic FGE estimates were within 3-25 % of estimates by Fyke netting and acoustic sampling in previous years for the same intake and season. The mean difference among 10 paired estimates was $10.7 \pm 5\%$, where 5% is a 95% confidence interval. The 1996 estimates were based upon sampling 24-hours per day for each season, whereas estimates from previous years were based upon daytime or early night samples.

1 Introduction

Construction and evaluation of surface collectors to meet the goal of 80 percent fish passage efficiency (FPE) for salmon smolts passing the Bonneville Project will require extensive research. Project FPE is defined as the percent of all smolts passing the project by non-turbine routes, and its evaluation requires measurement of smolt passage through all significant routes. Estimating FPE and quantifying any enhancement by surface collectors will be difficult because the Bonneville Project is among the most complex on the Columbia River. From the Oregon shore north toward Washington, the project is composed of a navigation lock, a 10-unit Powerhouse 1, Bradford Island, an 18-gate spillway, Cascades Island, and an 8-unit Powerhouse 2. Principal passage routes include the spillway and two powerhouses, but within each powerhouse, passage can be through ice/trash sluiceways, turbines, or the juvenile bypass system (JBS). Smolts enter the JBS after they encounter traveling screens in the upper part of turbine intakes and are diverted to gatewell slots and orifices opening to a bypass channel.

This Technical Report describes results of studies conducted by US Army Engineer District, Portland (CENPP) and the US Army Engineer Waterways Experiment Station (CEWES) to resolve critical uncertainties in the implementation of smolt-collector technologies and measurement of FPE at Bonneville Dam. Studies in FY 1996 addressed questions of immediate concern for installation of prototype surface collectors in FY 98 or FY 99 and some strategies for measuring select components of FPE.

Available biological information is inadequate to design and locate successful surface collector prototypes at Bonneville Dam (Giorgi and Stevenson 1995). Information on the vertical and lateral distributions of smolts in forebay areas of both powerhouses and spillway is very limited. No mobile hydroacoustic sampling has been conducted, and the proportion of smolts approaching Powerhouse 1, the spillway, and Powerhouse 2 has not been estimated.

Diel (24 hour) patterns of smolt passage are not uniform regardless of whether passage is measured in sluiceways (Uremovich et al. 1980; Willis and Uremovich 1981) or the JBS (Hawkes et al. 1991; Wood et al. 1994). Diel passage through the JBS often has a bimodal distribution with a major peak occurring just after dark and a minor peak after sunrise. In contrast, passage through the sluiceway usually is higher during the day than at night (Willis and Uremovich 1981). However, patterns apparently are influenced by the operation of sluice gates (Uremovich et al. 1980), flow, unit outages, and species (Willis and Uremovich 1981). Hydroacoustic and Fyke-net measures of fish-guidance efficiency (FGE) are intensive but usually limited to a few hours per day and therefore do not provide diel information. Diel patterns of passage have important implications for statistical designs to estimate FPE at all three dam structures at Bonneville.

Data on vertical distributions of smolts in forebay areas are limited to fixed-aspect hydroacoustic samples taken in front of trash racks of several turbine intakes at both powerhouses. The Fishery Field Unit sampled smolts with up-looking transducers at several units of Powerhouse 2 in 1985 (Nagy and Magne 1986) and of Powerhouse 1 in 1986. Similar vertical data were collected at the north end of Powerhouse 1 in 1995 with a deployment of down-looking transducers (Ploskey et al., In review). A problem with both data sets is that numbers of smolts in the upper water column (< ca. 6 m) were underestimated during the day because densities often were too high to accurately count fish. Nevertheless, these data clearly show a downward shift in the vertical distribution at night and a strong skew toward the surface during the day. Although these data reveal nothing about vertical distributions of smolts > 10 m upstream from structures, they do have implications for selecting depths of collector openings and for explaining day/night differences in FGE.

Available data indicate that the horizontal distribution of smolt passage among intakes is not uniform. Lateral distributions of smolts sampled in gatewells of Powerhouse 1 apparently are influenced by the number and location of operating units and sluice gates as well as the species of smolt (Willis and Uremovich 1981). Interactions among factors may account for a lack of consistency in measures of horizontal patterns by Uremovich et al. (1980), who found concentrations at units 6, 7, and 10, Willis and Uremovich (1981), who found variable patterns depending on operations, and Krcma et al. (1982), who observed most passage at units 4-6. Hydroacoustic sampling in front of intakes 8c-10b of Powerhouse 1 from 2200 through 0100 hours in June 1995 showed a distribution highly and consistently skewed toward Unit 10 (Ploskey et al., In review). Units 3, 4, and 6 were inoperable at the time of sampling. Considerable amounts of FGE data collected at Powerhouse 2 with in-turbine hydroacoustics (e.g., Magne et al. 1989; Stansell et al. 1990) and Fyke nets (Gessel et al. 1988; Muir et al. 1989) are of limited value for evaluating the lateral distribution of passage because they typically focused on one or two units at a time. Hydroacoustic sampling of smolts passing through several spillway gates was attempted in the mid 1980's by the Fishery Field Unit. Transducers were mounted on the bottom of gates and aimed upward in the water column and out from the gate. Apparently, noise generated by sound echoing off of vortices at some gates masked echoes from smolts and prevented a uniform distribution of sampling effort among gates. The assumption of equal sampling volume among transducers is critical for unbiased estimation of FPE.

Hydroacoustics also has been used on limited spatial and temporal scales to evaluate sampling potential or relative passage among a few routes. Thorne and Kuehl (1989) evaluated the effects of noise on hydroacoustic assessment of passage within several turbines of Powerhouse 1. Results showed that acoustic sampling was feasible at the units they tested. Magne et al. (1986, 1987, 1989) and Stansell et al. (1990) compared smolt passage through turbine units 11 and 17 with passage estimates obtained by Fyke netting and found reasonably good correlation for acoustic and Fyke-net FGE.

The goals for the FY 96 studies were to provide biological information necessary to facilitate the design and placement of a surface-collector prototype and to continue progress toward measuring Project FPE. Prioritized objectives included:

1. Use mobile hydroacoustics to measure the vertical and horizontal distribution of salmon smolts in forebay areas of both powerhouses and to characterize the day and night variation in spring and summer. This task was designed to provide guidance on the location and depth of openings of prototype surface collectors under prevailing operations in FY 96.

2. Estimate smolt passage into two turbines and the center sluice gate above each turbine, as well as the FPE ratio for the paired sluiceway/turbine openings under two test treatments for spring and summer at Powerhouse 1. Test treatments included alternating trash rack blocks between the two turbine units weekly and opening or closing of center sluice gates above test units according to a treatment schedule. Blocking trash racks served to increase the depth of the zone of separation between flow entering a turbine and flow entering a sluice gate. Opening a center sluice gate provided surface flow above the unit intake.
3. Estimate guided and unguided smolt passage into eight turbines of Powerhouse 2 and identify effects of the sluice chute on FGE of adjacent turbine units. The sluice chute was opened or closed for randomly selected 24-hour periods to provide treatments for evaluating its effect on Powerhouse 2 FPE in spring and summer.
4. Evaluate smolt behavior in terms of swimming direction in the area immediately upstream of two test units at Powerhouse 1, particularly near the zone of separation between flows entering turbines and flows entering sluice gates.

2 Materials and Methods

Mobile Hydroacoustic Surveys

Each season, we conducted six day and six night mobile hydroacoustic surveys in forebay areas of Bonneville Dam. Day surveys began about 1000 hours and night surveys about 2100 hours. Transects parallel to and located 10, 20, 30, 40, 50, 75, 100, 125, 150 m upstream of each powerhouse were sampled sequentially in opposite directions beginning at the powerhouse and moving upstream. Transect spacing was stratified to focus effort on forebay areas immediately upstream of each powerhouse. Transects were located 10 m apart in areas within 60 m of each powerhouse, 25 m apart in areas 75-150 m upstream, and 150-1000 m apart upstream toward the Bridge of the Gods (Figure 1). A BioSonics ES 2000 echosounder was used to transmit 420 kHz sounds from a 6 x 15 degree dual-beam transducer mounted on a BioSonics Biofin and deployed from a boom off the bow of a 24-ft boat. Target-strength information from the dual-beam transducer theoretically allowed us to count echo traces composed of smolt-sized targets and traces from larger fish. The ping rate during sampling was 10 pings per second in spring and 15 pings per second in summer. February 1996 calibration data for the transceiver and dual-beam transducer was used to set receiver gains (the amount of signal amplification) to avoid echo saturation from the largest targets of interest while amplifying echoes from fish with a target strength as low as -60 dB || 1 μPa. The sounder was controlled with BioSonics Dual-beam Multiplex software running on a 66 MHZ, 486 Austin laptop computer with a BioSonics Echo Signal Processing (ESP) board.

Densities of smolt-sized targets per m^3 were estimated for each 1-m depth interval and associated with a latitude and longitude from a Trimble Pathfinder Pro-XL geographical position system (GPS). Surveys within 150 m of each powerhouse had sub-meter position accuracy as the position dilution of precision (PDOP) was consistently < 4.0. Differential corrections were obtained from a Bureau of Land Management Bulletin Board in Portland, Oregon, and applied to position data after surveys were completed. Occasionally the PDOP exceeded 4.0 near the beginning or end of long transects located upstream of the Boat Restricted Zone (BRZ) and positions either had 1-10 m accuracy or were extrapolated from lines fitted to more reliable positions in the transect.

Dates of mobile surveys were selected to coincide with specific test treatments (Table 1). The goal was to survey three times while Unit 3 trash racks were blocked and three times when Unit 5 trash racks were blocked each season. Similarly, the schedule provided three day and night surveys when the sluice chute at Powerhouse 2 was open and three day and night surveys when it was closed each season.

Table 1							
		SPRING				SUMMER	
Day	Unit 3	Unit 5	Mobile	Day	Unit 3	Unit 5	Mobile
			Survey				Survey
26 Apr - Fri	UC	BO		14 Jun - Fri	BO	UC	
27 Apr - Sat	UO	BC		15 Jun - Sat	BO	UC	
28 Apr - Sun	UC	BO		16 Jun - Sun	BO	UC	
29 Apr - Mon	UC	BO		17 Jun - Mon	BC	UO	
30 Apr - Tue	UO	BC	X	18 Jun - Tue	BC	UO	
1 May - Wed	UO	BC		19 Jun - Wed	BO	UC	
2 May - Thu	UC	BO		20 Jun - Thu	BO	UC	X[1]
3 May - Fri	BO	UC		21 Jun - Fri	UC	BO	
4 May - Sat	BO	UC	X	22 Jun - Sat	UC	BO	
5 May - Sun	BC	UO		23 Jun - Sun	UO	BC	X[1]
6 May - Mon	BC	UO		24 Jun - Mon	UC	BO	
7 May - Tue	BO	UC		25 Jun - Tue	UO	BC	
8 May - Wed	BO	UC	X	26 Jun - Wed	UO	BC	
9 May - Thu	BC	UO		27 Jun - Thu	UC	BO	X
10 May - Fri	UC	BO		28 Jun - Fri	BC	UO	
11 May - Sat	UO	BC		29 Jun - Sat	BC	UO	X
12 May - Sun	UC	BO	X	30 Jun - Sun	BO	UC	X
13 May - Mon	UC	BO		1 Jul - Mon	BC	UO	
14 May - Tue	UO	BC		2 Jul - Tue	BC	UO	
15 May - Wed	UC	BO	X	3 Jul - Wed	BO	UC	X
16 May - Thu	UO	BC		4 Jul - Thu	BO	UC	
17 May - Fri	BC	UO		5 Jul - Fri	UO	BC	
18 May - Sat	BC	UO	X	6 Jul - Sat	UO	BC	
19 May - Sun	BC	UO		7 Jul - Sun	UC	BO	X
20 May - Mon	BO	UC		8 Jul - Mon	UO	BC	
21 May - Tue	BO	UC		9 Jul - Tue	UC	BO	X
22 May - Wed	BC	UO		10 Jul - Wed	UO	BC	
23 May - Thu	BO	UC		11 Jul - Thu	UC	BO	
24 May - Fri				12 Jul - Fri			

[1] Surveys with invalid bottom settings that were repeated

Powerhouse 1 Passage at Manipulated Units and Sluice gates

Turbine Passage. At Powerhouse 1, the WES estimated smolt passage into Units 3 and 5 in two manipulative tests in two experimental tests each season. One test evaluated the effect of partially blocked versus unblocked turbine units, and the other evaluated effects of open or closed sluice gates. Trash racks of one unit were blocked to the maximum possible elevation, i.e., 10.1 m mean sea level (MSL), while those of the other unit were left unblocked. Blocked racks were moved weekly between test units, whereas the sluice opening above the center intake of test units was opened or closed according to the test design in Table 1. Fiscal constraints precluded moving the blocks more than three times per season. Units 3 and 5 were selected because they were thought to be far enough apart to minimize interaction effects due to flow. Units 4 and 6 were both inoperable throughout FY 96 sampling. Blocked trash racks were moved on Fridays, and relocation required about 8 hours. Chain-gate and sluice-chute changes were made between 0700 and 0900 hours so that day and night mobile surveys on the same day would have the same treatment.

In-turbine acoustic samples of passing smolts were made with a pair of 6-degree, 420-kHz, single-beam transducers mounted on trash racks inside every intake of turbine units 3 and 5 for four weeks in spring and four weeks in summer. Each turbine intake is protected from debris by six 3.6-m-tall x 6.4-m-wide trash racks that are stacked vertically in the most upstream slot. The first transducer of each pair was mounted on the downstream face and south end of the uppermost trash rack in the intake opening and aimed downward to sample unguided smolts passing below the traveling screen. It was aimed 24 degrees off of the downstream face of the trash rack and about 7 degrees north of vertical so that the distal end of the acoustic beam was centered from north to south on the intake floor. A 0.3- x 0.6-m hole had to be cut in the plywood block of the top trash rack to accommodate the transducer. The second transducer of each pair was mounted on the fifth (always unblocked) trash rack from the surface and aimed upward to sample fish passing above the tip of the screen. It was aimed about 21 degrees off of the downstream face of the trash rack and to the north of vertical 10 degrees to center the distal end of the acoustic beam from north to south on the intake ceiling. A system consisting of one Model 103 echo-sounder and six transducers made by Precision Acoustic Systems (PAS) Incorporated, Seattle, WA, were deployed to sample Unit 3 and another identical system was used to sample Unit 5. Each system was controlled by a Zeos 100-MHZ Pentium computer and HARP software by Hydroacoustic Assessments, Seattle, WA. We slow multiplexed among the three pairs of transducers per unit (i.e., rotated sampling among intakes) every 5 minutes, and sampled 24 hours per day, except for occasions when a computer locked up and was not restarted until the problem was discovered. Paired transducers per intake were sampled simultaneously by alternating pings at a rate of 30 per second or 15 pings per second per transducer. This ping rate provided essentially uniform detection of juvenile salmonids over the ranges sampled, given maximum in-turbine flows through beams of about 1.4 m/second. Flow estimates were obtained from runs of a 1:25 physical model of a Powerhouse 1 turbine with a traveling screen. Parameters used in detection modeling included ping rate, a circular 8-degree effective beam pattern, beam angle relative to fish trajectory, detection threshold, fish velocity, minimum and maximum range, mean target strength, minimum number of pings required. Criteria for accepting echo traces as guided fish were range = 5.9-13.8 m, 3-10 echoes per trace, linearity > 0.995, and -0.03 < slope < 0.03. Criteria for accepting echo traces as unguided fish were range = 5.9-17.5 m, 3-15 echoes per trace, linearity > 0.995, and slope > 0.01 m/ping.

About 2,500 hours of in-turbine data were processed using an automated tracking program developed during this project. About one fifth of these echograms also were processed by people visually

identifying echo traces as fish and appending trace statistics to a data base. An hour of data requires from 0.75-1.5 hours to process visually but only minutes with the automated tracking program, after the program is properly calibrated to perform like a visual tracker. We checked the quality of performance of the calibrated autotracking program by correlating numbers of fish tracked visually with the numbers tracked automatically. The correlation coefficient was 0.91 ($r^2 = 0.83$) for a sample of 253 paired estimates of fish / hour by both methods. Fish numbers in about 12 five-minute echogram segments were counted separately by both methods and summed for every day of sampling. About 50 percent of the 5-minute data segments came from night hours and the other 50 percent from day hours. Similarly, one half of the numbers was from transducers sampling guided fish, while the other half was from transducers sampling unguided fish. The equation describing the relation of counts based upon the two processing methods was log(visually tracked fish) = 0.910 × log(auto-tracked fish) + 0.095. Correlations between tracking methods were very similar for guided and unguided counts processed separately (guided: r^2=0.85, N=134; unguided: r^2=0.81, N=120). All results presented in this report were based upon automated processing to increase consistency and the robustness of data sets.

Cable routing from the echosounders to transducers had to allow for the upper three trash racks of each test unit (one set of racks blocked and the other unblocked) to be swapped weekly. Belden deck cables were routed from a mobile trailer located on the forebay deck (elevation 90 feet mean sea level) at Unit 4B, through a grating and under the crane tracks, and up to the hand railing. Deck cables were tie wrapped along the rail and routed to the pier immediately south of the intake to be sampled. At the pier point, the deck cables were attached to armored cables that were routed through 0.3-m-long, 7.6-cm diameter pipes welded to the downstream side and south end of each trash rack. Pieces of pipe were welded within 1 m of the top and bottom of each rack and permitted the upper three racks to be removed by feeding armored cable through the pipe as the crane lifted each rack until the cable cleared the pipe. Installation of each of the upper three racks required us to feed armored cable up through the pipe as each rack was lowered. Down-looking transducers mounted on the uppermost trash rack and their associated armored cables were moved between test units when the upper three racks were swapped among test units each week. As a result, down-looking transducers were controlled by different echosounders each week and calibration settings and receiver gains had to be changed accordingly in the controlling software before sampling resumed.

Numbers of tracked fish were expanded based upon the ratio of intake width to the diameter of the hydroacoustic beam at given range:

$$\text{Expanded Numbers} = 6.5 / (\text{MID\_R} \times \text{TAN}(\text{B0}/2) \times 2)$$

where 6.5 is the width of the intake in m, MID_R is the mid-point range of a fish trace in m, TAN is the tangent, and B0 is beam angle in degrees. This expansion was necessary to allow us to estimate passage of juvenile salmonids without bias associated with range-dependent sample volume. Beam angle depends upon the average target strength of fish because larger fish can be detected farther away from the main axis of the acoustic beam than smaller fish. We estimated the target strength and associated beam angle for smolt-sized targets by solving for target strength in an equation relating target strength to fish length (Love 1977) using length-frequency data on smolts sampled in the juvenile bypass each season by the NMFS.

Sluice Passage. Smolt passage into center sluice gates at intakes 3B and 5B was sampled with two separate up-looking 6-degree, 420-kHz, split-beam transducers located 1.5 m upstream of the south

pier at depths of 9 and 13 m, respectively. Split-beam transducers were mounted on a trolley fitted to a 18-m-long 15- x 15-cm wide flange that was attached vertically to the upstream edge of the adjacent pier. Transducer trolleys were lowered to depths of 13 m at Unit 5 and about 9 m at Unit 3. Depths were limited by warp in the 15- x 15-cm wide flange that prevented trolleys from moving past certain points. The warp was caused when divers tightened bolts securing the flange to the pier. Split-beam sampling was continuous (24 hours / day) at open center sluice gates after the 14 May 1996 installation, except on occasions when data acquisition inadvertently stopped due to computer-interrupts until the problem was discovered and corrected.

Passage of smolts over the center sluice gate at Intake 5B also was monitored using video cameras and infrared lights during spring and summer 1996. Four black and white cameras (Sony SSC-M350) and eight sets of lights (American Dynamics 30 watt, 50 degree LED banks) were mounted to the upstream side of the 6.4-m-wide chain gate and aimed upward toward the water's surface. Two infrared lights were placed on either side of every camera lens and aimed upward. Cameras and lights were powered by a Sony camera adapter YS-W230 and Tripp-Lite 110 VAC to 13.8 VDC PR-15 power converters, respectively. Video images were recorded using either a Sony HI8 EV-C200 Real Time recorder or a Sony EVT-820 Time Lapse recorder. Real time video was sampled at a rate of 30 frames/sec, allowing for three hours of real time video data to be captured on 180 minute metal evaporate tapes. Time lapse video was sampled at a rate of 4 frames/sec, allowing for 16 hours of time lapse video data to be captured on 120 minute tapes. Sequential sampling across all four cameras at one minute intervals was performed using a Sony YS-S100 intelligent sequential switcher. Video images were viewed with Sony SSM-171 black and white image monitors.

According to the treatment schedule (Table 1), the chain gate was lowered via the Gantry crane to the elevation at which the bottom of the camera mount rested on the sill of the intake, leaving the face of the cameras at elevation 21.3 m MSL. Video recording was continuous as long as Sluice Gate 5B was open. Generally and whenever feasible, real-time video data were collected during the day and time lapse video data were collected during the night. Infrared lights were turned on approximately at 1700 hr during each day of video recording.

Video counts of smolt passage were expanded both spatially and temporally. The cross-sectional area of a single camera's field of view based on a viewing distance of 0.61 m was calculated and multiplied by a factor of four to account for total coverage of all cameras. Cross-sectional area of water passing over the gate was calculated for each treatment day (variable due to fluctuating forebay levels) and divided by the cross-sectional area of camera coverage resulting in a factor used to expand counts to accommodate total coverage. Finally, counts were multiplied by a factor of five to account for our sub-sampling of 12 minutes for every hour of video data.

Correlation analysis was used to determine whether acoustic and video methods of estimating sluice passage of smolts provided concordant results. Passage estimates from both methods were used to estimate smolt passage into the center sluice opening and FPE for test units when the sluice gate was open. Days were the experimental unit for evaluating effects of trash-rack blocks and center sluice-gate openings on five measures of smolt passage (Table 2).

Table 2		
Variable Name	**Abbreviatio**	**Definition**
		Smolt Passage Variables
Standardized Turbine Passage into	STP	Standardized turbine passage (STP) is the number of smolts passing into
Fish Guidance Efficiency	FGE	Fish-guidance efficiency (FGE) of in-turbine screens is the percent of all
Fish Passage Efficiency	FPE	Fish passage efficiency (FPE) is percent of smolts passed by non-turbine
Standardized Sluice Passage	SSP	Standardized sluice passage (SSP) is the number of smolts passing into
Sluice Passage Efficiency	SPE	Sluice-passage efficiency (SPE) per turbine unit is the percent of all
		Treatment or Location Variables
Block and Sluice Treatment	TREAT	Blocked and open = BO; Blocked and closed = BC; Unblocked and open
Block Treatment	BTRT	Upper three trash racks blocked or unblocked without regard to sluice
Sluice Gate Treatment	GTRT	Center sluice gate open or closed without regard to block treatments at
Sluice-chute Treatment	CTREAT	Sluice chute at Powerhouse 2 open or closed for 24 hours
Turbine Unit	UNIT	Turbine Unit 3 or 5
Turbine Intake	INTAKE	Turbine Intake 3A, 3B, 3C, 5A, 5B, and 5C

Smolt Behavior Upstream of Test Units and Sluice Gates. The WES used split-beam hydroacoustics to evaluate smolt swimming direction relative to flows in the area upstream of Unit 5 at Powerhouse 1. Near-field measurements of flow were obtained with an acoustic Doppler current profiler and a Gurley flow meter by the WES Hydraulics Lab under several treatment conditions. Acoustic sampling of smolts focused upon the zone of separation between flows entering turbines and those entering sluice gates at night and during the day under different test conditions. The null hypothesis for trash-rack blocks was that smolts would not cross the zone of flow separation or strong velocity gradients. A 6-degree, 420 kHz, PAS split-beam transducer was attached to a dual axis rotator (Remote Ocean Systems Model PT-10). The rotator was mounted on a trolley that rolled up or down on a 15- x 15-cm wide flange attached to the pier just south of Intake 5B. By raising or lowering the trolley and rotating the transducer aiming angle, we were able to sample from a down-looking or up-looking position. The up-looking deployment was described earlier under Task II. In the down-looking deployment, the transducer was aimed 7 degrees north of the east-west vertical plane and downward to intersect the trash rack at a range of 15 m. This maximum range was 2.5 m below the bottom of the trash-rack block. Both the up-looking and down-looking deployments were sampled for two 24-hour periods each season.

Powerhouse 2 Passage

The WES estimated guided and unguided smolt passage in eight turbines, the horizontal distribution of passage through the Powerhouse 2, and effects of the sluice chute on the FGE of adjacent units in spring and summer 1996. The sluice chute was opened or closed for 24-hour periods according to a stratified random design (Table 3).

Table 3

Day	Spring Sluice	Mobile Survey	Day	Summer Sluice Chute	Mobile Survey
26 Apr - Fri	O		1 (14 Jun - Fri)	C	
27 Apr - Sat	C		2 (15 Jun - Sat)	O	
28 Apr - Sun	O		3 (16 Jun - Sun)	O	
29 Apr - Mon	O		4 (17 Jun - Mon)	C	
30 Apr - Tue	C	X	5 (18 Jun - Tue)	O	
1 May - Wed	C		6 (19 Jun - Wed)	C	
2 May - Thu	O		7 (20 Jun - Thu)	O	X[1]
3 May - Fri	C	X	8 (21 Jun - Fri)	C	
4 May - Sat	C		9 (22 Jun - Sat)	O	
5 May - Sun	O		10 (23 Jun - Sun)	C	X[1]
6 May - Mon	O		11 (24 Jun - Mon)	C	
7 May - Tue	C		12 (25 Jun - Tue)	O	
8 May - Wed	O	X	13 (26 Jun - Wed)	O	
9 May - Thu	C		14 (27 Jun - Thu)	C	X
10 May - Fri	O		15 (28 Jun - Fri)	C	
11 May - Sat	C		16 (29 Jun - Sat)	O	X
12 May - Sun	O	X	17 (30 Jun - Sun)	O	X
13 May - Mon	O		18 (1 Jul - Mon)	C	
14 May - Tue	C		19 (2 Jul - Tue)	C	
15 May - Wed	C	X	20 (3 Jul - Wed)	O	X
16 May - Thu	O		21 (4 Jul - Thu)	C	
17 May - Fri	C		22 (5 Jul - Fri)	O	
18 May - Sat	O	X	23 (6 Jul - Sat)	O	
19 May - Sun	C		24 (7 Jul - Sun)	C	X
20 May - Mon	O		25 (8 Jul - Mon)	O	
21 May - Tue	C		26 (9 Jul - Tue)	C	X
22 May - Wed	C		27 (10 Jul - Wed)	O	
23 May - Thu	O		28 (11 Jul - Thu)	C	
24 May - Fri			29 (12 Jul - Fri)		

[1] Surveys with invalid bottom setting that were repeated.

Days were the experimental unit for evaluating effects of sluice-chute opening, and the test parameter was the FGE of adjacent turbine units (i.e., units 11 and 12). Unlike estimates of sluice-chute or turbine passage, FGE should be relatively independent of the number of smolts passing Powerhouse 2 on a given day.

In-turbine acoustic counts of smolts passing above and below traveling screens were made with paired, 6-degree, 420-kHz, single-beam transducers inside of eight intakes, each selected randomly from the three intakes composing every turbine unit. One transducer of each pair was mounted in the top of the second trash rack below the water surface and aimed downward to sample smolts passing below the screen. Initially, all down-looking transducers were mounted 0.5 m to the right of the vertical center of the trash rack and in the uppermost compartment. They were aimed 30 degrees off of the downstream face of the rack and along the east-west vertical plane. A second transducer of each pair was initially mounted near the vertical center of the fourth trash rack from the surface and aimed upward and downstream off of the face of the trash rack 25 degrees to sample fish passing above the tip of the screen. Armored cables were routed up the centerline of trash racks and through shackles welded to cross members near the top and bottom of each rack. All turbine units were running during spring and the first week of summer, but Unit 11 broke down and was out of commission thereafter.

Strong lateral flow toward the south end of Powerhouse 2 and turbulence created by flows passing TIES caused armored cables at Units 11 and 12 to vibrate wildly. Vibration either broke stainless steel Kellum grips near the transducer or on the 90 deck or rubbed the shackle pins through the armor causing an electrical short. After several failures of armored cable at intakes 11A and 12A, both down- and up-looking-transducers were moved from near the centerline to the sides of trash racks and aimed 7-10 degrees to the north or south of vertical to place the distal end of the acoustic beam near the center of the intake floor and ceiling, respectively.

One PAS-103 echosounder and eight transducers were deployed to sample intakes 11A, 12A, 13C, and 14B, and another identical system was used to sample intakes 15B, 16C, 17B, and 18A. Each system was controlled by a Zeos 100-MHZ Pentium computer and HARP software. We slow multiplexed among four pairs of transducers (i.e., rotated sampling sequentially among intakes) every 5 minutes, and sampled 24 hours per day, except when cables failed or on occasions when a computer locked up and was not restarted until the problem was discovered. Paired transducers per intake were sampled simultaneously by alternating pings at a rate of 30 per second or 15 pings per second for each transducer. This ping rate provided essentially uniform detection of juvenile salmonids over the ranges sampled, given maximum in-turbine flows through beams of about 1.4 m/second. Parameters used in detection modeling were the same as those used for Powerhouse 1 turbines. Criteria for accepting echo traces as guided fish were range = 4.6-10.8 m, 3-10 echoes per trace, linearity > 0.999, and -0.03 < slope < 0.03. Criteria for accepting echo traces as unguided fish were range = 4.8-17.5 m, 3-15 echoes per trace, linearity > 0.999, and slope > 0.01 m/ping. Numbers of tracked fish were expanded based upon the ratio of intake width to the diameter of the hydroacoustic beam at given range as described earlier under Powerhouse 1 Passage at Manipulated Unit and Sluice Gates.

On three dates in spring and two in summer, we unsuccessfully attempted to acoustically sample smolts passing into the sluice chute at Powerhouse 2 using either a 7-degree, 120-kHz transducer and echosounder made by PAS, Incorporated, or 6-degree, 420-kHz, single- or split-beam transducers and echosounders made by BioSonics Incorporated, Seattle, WA. Initial attempts involved mounting a transducer 1 m deep on a pole attached to the middle of the south side of the turbine intake extension

(TIE) on Intake 11A (5 m from the face of the powerhouse). The transducer was aimed horizontally south across the sluice opening. A dual axis rotator (Remote Ocean Systems Model PT-10) was programmed to repeatedly aim the single transducer 4, 7, and 14 degrees below the horizontal every 5 minutes to sample different depths. A second deployment involved mounting a transducer or a rotator and transducer on a pole extending out 3 m horizontally from upstream side of the sluice gate. The pole was mounted 1 m below the top of the gate so that opening the sluice gate lowered the transducer about 4.5 m below the water's surface. The transducer was aimed downstream 10 degrees from the vertical plane.

3 Results

Mobile Hydroacoustic Surveys

Overview

Locations of mobile hydroacoustic transects in forebay areas of Bonneville Dam are illustrated in Figures 1-3. Mobile samples could not be taken behind log booms and cables at Powerhouse 1 (Figure 2) or closer than about 20 m upstream of the face of Powerhouse 2 because of the presence of TIES. Within 30 m upstream of Powerhouse 1, 45 percent of the length of the dam could not be sampled because of the log booms and wire cable. From 40 to 75 m upstream, log-booms on the north and south side of the forebay prevented us from sampling the 5-19 percent of transects near shore. Sometimes transects at Powerhouse 2 had to be truncated because of floating logs and debris in the eddy at the north end of the forebay.

Plots of average densities of smolt-sized fish interpolated from transect data (Figures 4-19) or from densities in 1-m depth strata (Figures 20-27) do not account for variation among surveys and therefore must be tempered with results of statistical tests. For example, a plot showing high fish densities in a particular location may result from consistently high densities in most surveys or from very high densities in one or two of the six surveys per season.

Densities of smolt-sized fish usually were lower in upriver areas from the Bridge of the Gods down to the three-way split in the channel than they were near the powerhouses in spring (Figures 4 and 5) and particularly in summer (Figures 6 and 7). Highest densities of smolt-sized targets usually were in immediate forebay areas within 200 m of the dam (Figures 4-11), except for small areas downstream of islands upstream of the spillway in spring (Figures 8 and 9) or a larger area downstream (west) of the mouth of Eagle Creek in both seasons (Figures 8-11). In general, average fish densities were higher in summer than in spring, and average fish density patterns were similar for day and night surveys.

Powerhouse 1

In spring, average densities in the Powerhouse 1 forebay were higher in mid-channel areas than near shore (Figures 12 and 13) and lowest upstream of units 8-10. There were no significant differences in smolt density (number/m^3) among springtime transects upstream and within 75 m of Powerhouse 1, but there were differences in density among turbine units, and depth strata. There also was a significant interaction effect by at least two of the three dimensions. There were significant differences in springtime smolt density (number / m^3) among turbine units (lateral distribution) and among 6-m depth strata

(vertical distribution), but there was no effect of lateral position on vertical distribution (i.e., the interaction term was not significant). Mean densities were significantly higher upstream of turbine units 4-5 and 1-2 than they were upstream of units 8-9 and 10 north to Bradford Island. Mean density was higher upstream of units 4-5 than at all other units except Unit 1 south to the navigation lock wall. There were no significant differences in springtime smolt density among transects 1-5 (10-50 m upstream of Powerhouse 1) nor among transects 2-6 (20-75 m upstream).

In summer, average densities were more spread out along Powerhouse 1 and the north-shore of Bradford Island (Figures 14 and 15) than they were in spring. There were significant differences in summertime smolt density (number / m^2) among turbine units (lateral distribution) and a slight effect on transect distance upstream from the dam on that distribution (i.e., the interaction term was significant). There were no significant differences in smolt density (number/m^3) among transects upstream and within 75 m of Powerhouse 1 at $\alpha = 0.05$. There were significant differences in summertime smolt density (number / m^3) among turbine units (lateral distribution) and among 6-m depth strata (vertical distribution), but there was no effect of lateral position (UNIT) on vertical distribution (i.e., the interaction term was not significant).

Powerhouse 2

In both spring and summer, the average of six day or six night surveys usually showed the highest densities upstream of units 11-13 (Figures 16-19) and smaller patches of high densities upstream of Unit 18 or just north of Unit 18. In spring, we detected no significant differences in smolt densities among transects within 75 m of the dam, but there were differences among turbine units and 6-m depth strata. There was a significant interaction between effects of transects and turbine units on mean density, i.e., the lateral distribution changed as smolts approached the dam. Average springtime densities of smolt-sized fish upstream of Unit 18 were higher at night than during the day (compare Figures 16 and 17), and densities in the north corner of Powerhouse 2 were higher during the day than at night (compare Figures 18 and 19). In summer, a two-way ANOVA showed significant differences in mean numbers per m^2 among transects upstream and within 75 m of Powerhouse 2 and among turbine units, but there was no significant interaction between effects of transects and units, i.e., the lateral distribution apparently does not change as smolts approach within 75 m of the dam. In summer, mean densities were significantly higher upstream of turbine units 11, 12-13 and 18 than they were at units 14-15 and 16-17. No significant differences in means were detected among units 11, 12-13, and 18 nor among units 14-15 and 16-17.

At Powerhouse 2, vertical interpolations for transects 1 and 2 showed the highest concentrations of fish in the upper one third of the water column regardless of sluice- chute treatment or time of day in both spring (Figures 20-23) and summer (Figures 24-27). However, smolt-sized fish often were observed in low densities at depths > 15 m. Although variability among surveys was high, densities of fish at transects 1 and 2 tended to be higher during surveys when sluice chute was closed than when it was open (Figures 20-27), particularly in summer (Figures 24-27).

Changes in Vertical Distributions near Powerhouses

Average vertical distributions of smolt-sized fish at transects 50-70 m upstream of powerhouses usually differed from distributions at transects just 20 m upstream, but differences were not the same for both powerhouses. The vertical distribution of smolt-sized fish within 20 m of Powerhouse 1 was

consistently shallower than the distribution of fish 50-75 m upstream, regardless of time of day or season (Figures 28-31). In contrast, the vertical distribution within 20 m of Powerhouse 2 usually was deeper than the distribution of fish 50-75 m upstream (Figures 32-35).

Powerhouse 1 Passage at Manipulated Units and Sluice gates

Background

Variable names, abbreviations, and definitions used in the following description of effects are presented in Table 2. Results are presented by season and response variable, usually with two-way analysis of variance (ANOVA) tests described first followed by results of one-way-ANOVA and multiple-range tests. Variable names often are capitalized to make them easy to identify and reference to Table 2. Most ANOVA tables and multiple range tests are included as appendices to this report.

We found no significant correlation of sluice passage estimates from split-beam sampling with estimates from four underwater video cameras mounted on the sluice gate (Figure 36). Therefore, we relied upon camera counts in which we had a high degree of confidence for estimating smolt passage into the 5B sluice. We were forced to use split-beam estimates of the flux of smolts toward the sluice opening at 3B because cameras were not deployed there. Data from split beams at 3B and 5B were process in the same way. We used the net movement or flux of fish toward the sluice gate as a measure of passage because many fish also were tracked moving upstream through the beam and away from the open gate. Estimates required many assumptions about which fish were most likely to enter the sluice opening based upon their depth and direction of travel. We assumed that smolt-sized fish at depths from 2-4 m that were moving up in the water column and all smolts < 2 m deep were likely to pass into the sluice opening if they were moving downstream toward the center of the gate (± 45 horizontal degrees). However, we subtracted the number that were moving upstream away from the sluice gate from the number moving toward the gate because smolt-sized fish moved through the acoustic beam in all directions. Unfortunately, smolts were not committed to passing into the sluice when they were 3-4 m upstream of the gate, and up-looking split beams could not be aimed closer than 3-4 m upstream of the gate opening because a trash rack was placed there for boat safety. Normally, this top trash rack would not be present so that logs and debris would pass into the sluiceway. The only redeeming feature of the split-beam estimate of fish flux toward the gate was that it was always positive, i.e., the number moving downstream always exceeded the number moving upstream.

Spring

Standardized turbine passage (STP). The STP into turbines differed significantly among block treatments (BTRT) and turbine units (UNIT), but the interaction effect of BTRT and UNIT was not significant at $\alpha = 0.05$. The STP did not differ among combination block and sluice treatments (TREAT), probably because sluice-gate treatments (GTRT) had no significant effect. We also found no significant effect of the interaction term GTRT x UNIT. A two way ANOVA looking at the effect of BTRT and GTRT showed a significant effect of BTRT and no effect of GTRT or the interaction of BTRT and GTRT. Pooling data for units 3 and 5 despite differences among units showed that blocking upper racks significantly reduced STP from a mean of 0.32 to 0.19. At Unit 3, STP was lower when the upper three trash racks were blocked (mean = 0.014) than when they were unblocked (mean = 0.029) and STP did not differ among open and closed sluice gate treatments (GTRT). In contrast, we found no significant effect

of TREAT, BTRT or GTRT for Unit 5, so the significant BTRT effect for pooled data for both units was entirely due to effects at Unit 3.

Effects of treatments on STP also were examined by turbine intake and treatment. We found a highly significant effect of INTAKE, BTRT, and the interaction term INTAKE*BTRT. Intakes 3A, 3C, and 5A all had significantly lower mean STP when blocked than when unblocked. Blocking had no effect at intakes 3B or 5B, and Intake 5C showed the opposite effect (i.e., blocking doubled turbine passage). Pooled data for Unit 3 and 5 indicated lower STP during blocked than during unblocked treatments. The STP was higher at all unit 3 intakes and Intake 5A, which did not differ, than it was at intakes 5B and 5C.

Fish passage efficiency (FPE). The FPE for pooled data for units 3 and 5 was unaffected by combined block and sluice treatments (TREAT), units (UNIT), and the interaction thereof. It also was unaffected by block treatment (BTRT), sluice gate treatment (GTRT), and their interaction. The change in mean FPE among sluice-gate treatments (GTRT) was significant at Unit 5 but not at Unit 3, although the direction of change was similar for both units. At Unit 3, the mean for the open-gate-treatment was 58.6 percent relative to 40 percent for the closed gate treatment. At Unit 5, opening a center sluice gate significantly increased mean FPE from 27.5 to 63.0 percent.

Fish guidance efficiency (FGE). The FGE, which could only be estimated for unblocked treatments, was significantly affected by UNIT and INTAKE, but not by the sluice-gate treatment (GTRT) or the interaction of the INTAKE and GTRT. Mean FGE was higher at Unit 3 (49%) than at Unit 5 (29%), and within both units, FGE was consistently higher in the A intake than in the B and C intakes, which did not differ significantly (Figure 37). We found no significant difference in the mean FGE for closed- and open-sluice treatments at either unit (Figure 38 and 39). Mean FGE for unblocked treatments nearly differed significantly between day and night at Unit 3 (day = 74; night = 69; $P = 0.1140$; $N = 25$) and at Unit 5 (day = 45; night = 33%; $P = 0.1922$; $N = 19$).

Standardized sluice passage (SSP). The SSP was not significantly affected by block treatments, unit, nor the interaction effect of blocking treatments and unit. This result was consistent for pooled data for both units and for individual units. However, the ratio of blocked to unblocked means were consistently > 1, as follows: 4.8 (units pooled), 6.8 (Unit 3), and 2.2 (Unit 5), although variability in SSP was high in all cases. The probability associated with the statistical test on underwater video counts at sluice gate 5B was nearly significant at a 5 percent level ($P = 0.0809$), indicating higher sluice passage in spring during blocked treatments than during unblocked treatments.

Sluice passage over the diel cycle for selected spring days (Figure 40) shows that the majority of passage occurred during the early morning hours, with a peak at approximately 0300 hours. Passage was reduced during daytime hours and appeared to increase shortly after sunset. Hourly sluice passage over the spring migration season (Figure 41) shows a similar pattern, with peak passage occurring in the early morning hours then declining steadily to a much reduced daytime passage rate. A secondary peak is apparent shortly after sunset.

The horizontal distribution of smolt passage over sluice gate 5B (Table 4) was not uniform for spring migrants. A disproportionate number of smolts passed near the ends of the gate (especially the north end) than near the middle. This trend even more noticeable during the day than at night. An analysis of variance comparing mean proportional counts of end cameras (cameras 1 and 4 pooled) with

means for middle cameras (cameras 2 and 3 pooled) was significant. Passage events captured with real time sampling rates (30 frames per second) in the spring resulted in a mean of 2.7 and a maximum of 15 frames per event. Passage events captured with time-lapse sampling rates (4 frames per second) in the spring resulted in a mean and maximum of 1 frame per event.

Sluice passage efficiency (SPE). The SPE was significantly affected by unit, but not by block treatment, or the interaction of block treatment and unit. The ratio of blocked : unblocked means was as follows: 62.8 : 51.0 (units pooled), 40.4 : 25.8 (Unit 3), and 89.0 : 76.2 (Unit 5), respectively.

Summer

Standardized turbine passage (STP). The STP into test turbines differed significantly among block treatments (BTRT) and turbine units, and the interaction effect of BTRT x UNIT was significant. There was no significant effect of sluice gate treatment or the interaction of BTRT x GTRT. We processed data for the two units separately because of the strong effect of unit upon results. For Unit 3, blocked treatments with open or closed center sluice gates (TREAT) resulted in significantly lower mean STP (0.07 for open sluice and 0.09 for closed sluice) than did unblocked treatments (0.27). Mean STP did not differ between open and closed sluice treatments at Unit 3. At Unit 5, mean STP was significantly higher for blocked treatments with an open or closed center sluice gate (open mean = 0.92; closed mean = 0.97) than it was for unblocked treatments (closed mean = 0.33; open mean = 0.34), just the opposite of what was observed at Unit 3. At Unit 5 like at Unit 3, mean STP did not differ between open and closed sluice gate treatments.

Effects of treatments on STP also were examined by turbine intake and treatment. We found highly significant effects of intake, block treatment, and the interaction term INTAKE*BTRT in a two-way ANOVA. Intakes 3A, 3C, and 5B all had significantly lower mean STP when trash racks were blocked than when they were not blocked. Blocking had no significant effect on mean STP at intakes 3B or 5C at $\alpha = 0.05$, although the difference at 3B was nearly significant ($P = 0.0553$). Mean STP at intake 5A was higher under the blocked treatment than it was under the unblocked treatment. Intake 5A had a higher mean STP than all other intakes, which did not differ significantly.

Fish passage efficiency (FPE). The FPE for pooled data for units 3 and 5 was significantly affected by combined sluice treatments, units, and the interaction thereof. The highest mean was for the unblocked, open-sluice treatment (77.8%) which was significantly greater than the unblocked, closed sluice treatment (53.9%). For Unit 3, the mean FPE for the unblocked, open sluice treatment (87.0%) was significantly higher than mean for the unblocked closed treatments (56.3%), which did not differ. At Unit 5, means for the unblocked open (67.0%) and unblocked closed treatments (52.5%) did not differ.

Effects of sluice-gate treatment (GTRT) for data pooled for both units was not significant as it was confounded by a significant among-unit effect ($P = 0.0026$) and the interaction of GTRT x UNIT ($P = 0.0136$). For Unit 3, the mean FPE for the open sluice treatment (76.9%) was significantly higher than the mean for the closed sluice treatment (30.3%). Means for the same treatments at Unit 5, i.e., open sluice = 39.1% and closed sluice = 29.0%, did not differ at $\alpha = 0.05$.

Fish guidance efficiency (FGE). The FGE relative to in-turbine traveling screens was significantly affected by intake but not by sluice-gate treatment (GTRT), or the interaction of GTRT and intake. Mean FGE was higher for Unit 3 (57%) than for Unit 5 (49%) at $\alpha = 0.15$ ($P = 0.1378$). Estimates of FGE did not differ significantly among open- and closed-sluice treatments at either unit (Figures 42 and 43). Mean FGE was similar for intakes 3A, 3C, 5B, and 5C and ranged from 62 to 64%, and it was lower for intakes 5A and 3B, which did not differ significantly (Figure 44). Mean FGE did not differ between day and night periods at Unit 3 (day = 57%; night = 55%) or at Unit 5 (day = 50%; night = 44%).

Standardized sluice passage (SSP). The SSP was affected by block treatments, unit, and the interaction effect of TREAT and UNIT. For Unit 3, mean SSP was significantly higher for the unblocked, open-sluice treatment than it was for the blocked, open-sluice treatment. Blocked trash racks did not have a significant effect (alpha = 0.05) on video-monitored sluice passage at Intake 5B.

Sluice passage over the diel cycle for 18 June (Figure 40) shows that, as in the spring, the majority of passage occurred during the early morning hours, with a peak at approximately 3 a.m. Passage was reduced during daytime hours for 18 and 27 June, and increased sharply just after sunset. As in the spring, hourly sluice passage in summer peaked in the early morning hours and then declined steadily to a much reduced daytime passage rate (Figure 41). A secondary peak of higher magnitude than the secondary peak in spring was apparent shortly after sunset.

Analysis of variance on proportional counts for corner cameras (cameras 1 and 4 pooled) relative to middle cameras (cameras 2 and 3 pooled) showed that differences were significant. Passage events captured with real time sampling rates (30 frames per second) in the summer resulted in a mean of 2.9 and a maximum of 11 video frames per smolt. Passage events captured with time-lapse sampling rates at night (4 frames per second) in the summer resulted in a mean and maximum of 1 frame per smolt. However, trends in the horizontal distribution of passage were observed for both time-lapse and real-time sampling. Horizontal distribution of passage at Intake 5B in summer was similar to that observed in spring (Table 4). In both seasons disproportionate number of smolts passed near the ends of the sluice gate than passed over the middle. This trend was more noticeable at night than during the day in summer, just the opposite of the pattern observed in spring.

Sluice passage efficiency (SPE). (TREAT x UNIT). Means nearly differed among unblocked (46.0%) and blocked treatments (22.5%) for Unit 5 but not for Unit 3 (unblocked = 69.5%; blocked = 68.1%). Unit-three estimates were based solely on split-beam counts, whereas Unit 5 counts were based upon video counts.

Diel Trends in Spring and Summer

Mean hourly smolt passage into turbines generally was higher during night hours than during day hours in both seasons. Data were more variable in spring than in summer (Figure 45). The pattern of increased passage just after sunset is consistent with what has been observed for the juvenile bypass channel at Bonneville. However, passage though the bypass peaks just after sunset and then falls off during the night not unlike the pattern for spring. In summer, mean total passage into the turbine did not appear to decrease during the night.

Table 4						
Treatmen	Camera	Camera 2	Camera	Camera	N	
Spring	22.00	19.30	20.80	38.00	524	
Day	28.10	16.70	16.70	38.50	96	↑
Night	20.60	20.00	21.70	37.90	428	↑
						↑
Blocked	21.60	18.20	21.00	39.20	362	
Unblocked	22.80	21.60	20.40	35.20	162	
						F
Summer	31.50	18.70	15.60	34.10	577	L
						O
Day	31.10	13.50	20.30	35.10	74	W
Night	31.60	19.50	14.90	34.00	503	
Blocked	26.70	19.80	11.60	41.80	232	
Unblocked	34.80	18.00	18.30	29.00	345	

Smolt Behavior Upstream of Test Units and Sluice Gates

Split-beam acoustics were better suited for qualitative sampling of smolt behavior upstream of sluice gates than for making quantitative estimates of number of smolts passing into the 0.5-2-m deep surface sluice openings. Smolt-sized fish moved through the acoustic beam in all directions, although the number moving in a downstream direction always exceeded the number moving in an upstream direction. Clearly smolts in the acoustic beam were not committed to passage in the center intakes or sluice opening. We examined the number of smolts moving up and down in the water column relative to depth of fish and test treatments, including blocked or unblocked trash racks and open or closed center sluice gates. Most tests were on the ratio of fish moving up to the number moving down in the water column 3-4 m upstream of the intake 3B or 5B. At Intake 3B the ratio of upward-to downward-moving fish differed significantly between treatments. Means were 4.0 for the blocked, open-sluice treatment and 1.7 for the unblocked, open-sluice treatment at Intake 3B when all depth intervals were pooled. The mean number of fish moving up in the water column per treatment day was significantly higher during blocked, open-sluice treatments for fish at depths of 5-6 m for Unit 3 and at all depths for Unit 5 than it was for unblocked, open-sluice treatments (Figure 54). However, we found no significant effect of fish depth, test treatment, nor the treatment x depth interaction on the up:down ratio for Intake 5B (Figure 54) as nearly equivalent numbers of fish were detected moving up and down. At Intake 5B, numbers of upward and downward moving fish at all depths were higher during the blocked, open-sluice treatment than during the unblocked, open-sluice treatment, just the opposite of results for downward moving fish at 3-4 m of depth upstream of Intake 3B. Treatment means for all depths at Intake 5B were 1.3 for the blocked, open-sluice treatments and 1.1 for the unblocked, open-sluice treatment. Numbers of fish moving deeper in the 3-4 m

depth strata upstream of Unit 3 were higher during the unblocked, open-sluice treatment than during the blocked, open-sluice treatment (Figure 54). Differences at other depths were not significant.

Powerhouse 2 Passage

Spring

Two-way analysis of variance indicated that there were highly significant differences in standardized turbine passage (STP) among intakes, but effects of sluice-chute treatments (CTREAT) and the interaction of INTAKE x CTREAT were not significant at $\alpha = 0.05$ ($P < 0.1$). At Intake 11A, STP was 1.5 times higher on days when the sluice chute was closed than when it was open at $\alpha = 0.1$. Nothing approaching a significant effect of sluice-chute operations was detected for other intakes at Powerhouse 2. Analysis of total smolt passage into turbines intakes revealed that Intake 11A passed significantly more fish per unit of trackable time than all other monitored intakes.

Examples of diel cycles of turbine passage (Figure 46) showed a nighttime peak for a couple of treatment days, but the majority of days had no consistent pattern, as data were highly variable in spring. Expanded counts of smolts in the juvenile bypass (screen guided fish) from NMFS showed the springtime daily passage peak at 2200 hours (Figure 47). Total smolt passage by treatment day for the spring migration (Figure 48) shows a fairly consistent rate of passage for most of the first half of the season before peaking towards the end of the third and into the fourth week. This pattern also occurred in the plot of NMFS bypass data from the same period.

Analysis of fish guidance efficiency (FGE) showed significant differences among intakes (Figure 49), but no effect of sluice-chute treatment or an interaction term. Intake 12A that had no TIE had the highest mean FGE and differed significantly from all other intakes except 15B. Sampled intakes on either side of 12A with TIES both had lower FGE than 12A. Intake 11A had the lowest mean FGE and did not differ significantly from intakes 14B, 16C and 18A. Intakes 13C, 14B, 16C, 17B, and 18A also did not differ.

The spatial pattern of variable FGE estimates across the powerhouse was consistent for day and night periods of time (Figure 50). Sluice chute treatments had no significant effect on FGE by intake. Guidance efficiency by treatment day for the spring migration (Figure 48) shows a tri-modal pattern of equal amplitudes, with a substantial trough occurring towards the end of the third and into the fourth week. This temporal reduction in FGE coincides with the peak in total turbine passage for the spring migration (Figure 48). Mean FGE for the powerhouse was 37% in spring. Mean FGE for all intakes was significantly higher ($P = 0.0004$; $N = 350$) during the day (45%) than it was at night (27%).

Summer

A two way analysis of variance showed a strong effect of intake on standardized turbine passage (STP) but no effect of sluice-chute treatment or the interaction term INTAKE x CTREAT. Analysis of total smolt passage by intake for the summer migration showed that Intake 11A passed significantly more fish per unit of trackable time than all other monitored intakes, as it did in spring. However, turbine unit 11 was inoperable for most of the summer migration season, so the sample size for Intake 11A was small

(N = 5 treatment days) relative to the other intakes (sample sizes ranged from 21 to 28 treatment days). There was no effect of sluice chute treatment on standardized turbine passage at any intake.

The diel pattern of total smolt passage in summer had a pronounced peak during nighttime hours for the majority of days (Figure 51). The summer diel peak for TSP occurs either during the evening at 2200 to 2300 or the early morning hours of 0200 to 0400. Bypass data on screen-guided smolts from NMFS for 1996 shows daily peak passage during the summer migration at 2300 hours (Figure 47). The summer run pattern (Figure 52) was initially high during the first week (based on a couple of sharp spikes) then leveled out for two weeks before moderately increasing during the last week. Bypass data from NMFS depicts a general increase in the run through the summer season before peaking towards the beginning of the last week.

Analysis of guidance efficiency for the summer migration showed considerable differences among intakes (Figure 53) but no significant effect of the sluice-chute treatment or an interaction between CTREAT and INTAKE on FGE. Intake 12A had the highest mean FGE during the summer, and it differed significantly from Intakes 16C, 18A and 11A. Intake 11A had the lowest mean FGE and differed significantly from Intakes 12A and 14B. The spatial pattern of FGE estimates across the powerhouse depicts higher guidance efficiency among a group of adjacent units starting with Intake 12A and spanning to 15B. This pattern was consistent for day and night hours (Figure 53). The only difference was a shift of higher FGE among this group of intakes towards Intake 14B at night. Unlike patterns of FGE and turbine passage in spring, the summer pattern (Figure 52) shows highest turbine passage and guidance during the first week of the season, a decrease and leveling off through summer. Mean FGE across the powerhouse during summer was 26%. The mean for all intakes was significantly higher ($P = 0.0001$; $N = 417$) during the day (38%) than it was at night (25%).

4 Discussion

Inferences about Desirable Locations and Depths for Collectors

Low FGE of traveling screens in turbines of both powerhouses and a desire to increase Project FPE have been driving forces behind proposals to evaluate prototype surface collectors at Bonneville Dam. Results from 1996 sampling of smolt passage with hydroacoustics and cameras provide evidence that surface collection has promise to increase FPE at Bonneville Dam. The 1996 test results were not without ambiguities, many of which can be explained by high variability among days, turbine units, and intakes. Also sample sizes were limited by the duration of spring and summer runs and by significant differences in measures of smolt passage among units and intakes that kept us from pooling data to increase sample size and the power of statistical tests.

Mobile surveys showed significant longitudinal, lateral, and vertical gradients in smolt density that provide opportunities to optimize prototype location and configuration. High densities of fish estimated by mobile acoustics show where fish are holding, whereas areas with low densities suggest that fish either do not use an area or are moving more rapidly through it. For example, we consistently found low densities in the riverine area upstream of the boat restricted zone to the Bridge of the Gods and high densities in certain areas near both powerhouses.

At Powerhouse 1, mean densities generally were higher in mid-channel areas in spring and were more spread out along the powerhouse in summer. If this pattern is consistent in 1997 mobile surveys, a good test location for a prototype collector would be near the center of the powerhouse at units 3-5 or 4-6, especially in spring. Lateral densities at Powerhouse 1 in summer also suggest that many young-of-year smolts would encounter a centrally located collector, although smolts may be more dense along the north shore than at the center of the powerhouse. The highest densities of smolts in forebay areas in summer were 2.6 times higher than the highest densities in spring. Unfortunately, we could not be certain of the horizontal distribution near Powerhouse 1 because we could not survey the area immediately upstream of units 7 - 10 or along the north shore of Bradford Island because of a steel cable and log boom. However, we know from fixed-aspect sampling in June 1995 that the area north of Unit 7 had a high density of smolts in summer (Ploskey et al. In Review).

We found a consistent upward shift in the vertical distribution of smolts when comparing samples 50-75 m upstream of Powerhouse 1 to distributions 10-20 m upstream of the dam. This shift may be explained by smolts moving up in the water column as they approach the dam, a behavior that a surface collector could exploit. This distribution shift also might be caused by entrainment and removal of smolts

from depths greater than 8 m near turbine intakes, but we find it hard to believe that smolts 10-20 m upstream of turbines would be susceptible to entrainment or that they would mill around an area 1-20 m from the intakes in 1.2 m / sec flows. Radio tracking of smolts suggests that there is little horizontal movement along the powerhouse or milling (Rip Shively, Personal Communication). Nevertheless, both hypotheses for explaining the shift in vertical distribution should be tested by tracking smolts with depth sensitive radio tags or by passive split-beam tracking of smolts with ultrasonic tags.

Lateral distributions of smolts were more consistent for both seasons at Powerhouse 2 than at Powerhouse 1 and, if confirmed by 1997 mobile surveys, we would recommend intakes 11-13 or Unit 18 as good locations for a collector prototype because that is where we almost always observed the highest densities of smolts. With modification, the sluice chute near unit 11 also would be a good collector because of its proximity to relatively high densities of smolts holding upstream of Unit 11-13. In-turbine acoustic sampling also identified these units as having high passage rates. We usually found lower densities upstream of Unit 11-13 on days when the sluice chute was open than when it was closed suggesting that the chute reduced holding in the south eddy. However, we found no effect of sluice-chute operations on the fish-guidance efficiency of screens in adjacent intakes. Therefore, benefits of the sluice chute would appear to be solely a function of numbers of smolts it passed rather than altering depth distributions of smolts and increasing FGE of traveling screens. Laminar flows toward the chute opening likely could be increased by removing TIES on the south end of the powerhouse. In fixed-aspect sampling, we found that intakes with TIES passed significantly more fish but with a lower FGE than intakes without TIES. A potential problem with this interpretation is that sampled intakes with TIES were clustered in the south half of the powerhouse (i.e., 11A, 13C, and 14B) and differences in passage and FGE might be a function of location as much as intake shape. It is interesting that the highest FGE in spring and summer was observed at Intake 12A which was between low-FGE intakes with TIES. Mobile surveys in summer detected no significant interaction between effects of transects and units, i.e., the lateral distribution apparently does not change as smolts approach within 75 m of the dam. This result is consistent with observations by the NBS researchers tracking smolts (Rip Shively, Personal Communication). Gessel et al. (1988) observed higher FGE at intake 12A without a TIE (> 70%) than at intake 12B with a TIE (60%) and recommended alternating TIES on every other intake at Powerhouse 2..

We tried several times to sample the sluice chute with fixed-aspect hydroacoustics and failed each time because of high background noise from entrained air associated with a fully opened gate and turbulent flows moving around the end of the TIE on Intake 11A and up-welling flow upstream of the gate. Two cabled logs deployed upstream of the sluice-chute opening as a safety measure to prevent survey boats from being passed down the sluice way also may have contributed to background noise levels. However, some acoustic sampling was possible in 1988 when the gate was opened to elevation 21 m MSL or 1.5 m deep (Stansell et al. 1990) below normal pool elevation. Sluice passage, even with such a small opening, was about 60-63% of total passage through Unit 11 or 18 in spring and about 28 and 45% of total passage through Unit 11 and 18, respectively, in summer. Perhaps a larger opening would pass even more smolts and modification of the chute could turn the sluice into a valuable surface collector.

The sluice gate was fully open (elevation 18.6 m MSL or 3.96 m of depth below normal pool elevation 22.55 m MSL) during all of our attempts at monitoring. Our first attempt was with a 120 kHz split-beam transducer mounted on the TIE at 11A and aimed horizontally across the sluice opening. Sampling revealed a signal to noise ratio of about 1 even when the threshold was set to see fish > -44 dB

(about 150 mm long). This means that most yearling and all sub-yearling smolts could not be counted. We also sampled with BioSonics digital, 420-kHz, single- and split-beam transducers. Transducers were mounted 1-m below the top of the sluice gate on the end of a 3-m-long pole extending out into the forebay perpendicular to gate. Transducers were aimed upward and about 45 degrees downstream of vertical and provided a maximum range of about 4 m to the water's surface. Maximum beam diameter at 4 m is about 0.42 m, so the small sample volume should have greatly reduced volume reverberation. Nevertheless, noise from entrained air obscured smolts smaller than about -47 dB or about 100 mm long from reliable detection. Also, surges in turbulent flow moving around the TIE at 11A prevented reliable counting of larger smolts one fourth of the time.

The vertical distribution of smolts in the forebay upstream of Powerhouse 2 was strongly skewed toward the surface during most surveys but it was different within 20 m of TIES than it was 50-75 m upstream. The downward shift in the vertical distribution as smolts approached the dam was the opposite of what we observed at Powerhouse 1. The shift may be a function of approach hydraulics caused by the rapid increase in depth as smolts approach Powerhouse 2. Flows moving over the relatively shallow area (13.4 m deep) between transects 9 and 5 (Figure 3) probably decelerate and mix vertically as depths increased rapidly to 30 m over a horizontal distance of about 40 m. This possibility should be evaluated using physical models of the Powerhouse 2 forebay.

Inferences about Blocked Trash-Rack Effects

Blocking and unblocking the upper three trash racks down to a depth of about 13.4 m was designed to test the hypothesis that total smolt passage into a turbine or intake would decrease when racks were blocked. Biologists have hypothesized that smolts either would avoid rapidly accelerating flow or move up in the water column upstream of trash rack blocks. Another hypothesis was that sluice passage and the efficiency of the sluice relative to total passage (SPE) would be higher when racks were blocked than when they were not blocked. Estimates of FGE could not be made during blocked trash rack treatments because traveling screens were not installed behind blocks. Even if they had been installed, there was insufficient flow behind blocks to guide fish. Counts of smolts behind blocked trash racks were over five times higher than counts in the same intake area when racks were not blocked. Fish behind blocks were wallowing in and out of the up-looking acoustic beam and differences in blocked and unblocked counts likely resulted from multiple counts of milling fish in low velocity flows behind blocks. Consequently, we did not use counts of fish behind blocks to evaluate any treatment effects.

Although results were not consistently significant, there was considerable evidence that blocking trash racks (lowering the zone of flow separation) was beneficial. For example, total standardized passage was significantly less for blocked treatments (passage under blocks) than for unblocked treatments at Unit 3 in spring (53% less) and summer (70.3% less). Several individual intakes also showed significant differences. In spring, for example, intakes 3A, 3C, and 5A all had lower mean STP when racks were blocked than when they were unblocked. In summer, intakes 3A, 3C, and 5B all had lower mean STP when racks were blocked than when they were unblocked and differences at intake 3B was nearly significant ($P = 0.0553$). The only intakes with contrary effects, i.e., higher turbine passage when blocked than when unblocked, were intake 5C in spring and 5A in summer. Blocked trash-rack tests were based on relatively small sample sizes for each treatment (i.e., about $N = 14$) because differences among units and intakes made us cautious about pooling data to increase the power of tests.

The behavior of smolts upstream of trash racks also was informative. At intake 3B and depths of 5-6 m, the mean number of smolt-sized fish moving up in the water column and the ratio of upward- to downward-moving fish were both significantly higher for blocked than for unblocked treatments. At intake 5B, significantly more fish were moving up and down in the water column when trash racks were blocked than when they were unblocked (Figure 54). Milling of smolts upstream of the block does not and perhaps cannot occur during unblocked treatments because of flows into the intake. Milling may afford smolts time to discover the surface opening, but it also may make them more vulnerable to predation.

In spring, standardized sluice passage and sluice passage efficiency (SPE) did not differ significantly between blocked and unblocked treatments, but likely only because tests lacked sufficient power to reject the null hypothesis of no difference. The mean ratio of blocked to unblocked sluice passage was 6.8 for Unit 3 and 2.2 for Unit 5 ($P = 0.0809$; $N=6$). Non-significant increases in mean SPE resulting from blocking trash racks were +14.6% at Unit 3 and +12.8% for Unit 5.

In summer, blocking trash racks did not significantly increase standardized sluice passage or sluice passage efficiency. We found no effect of blocking on passage at 5B, which was monitored with confidence using underwater video cameras. In fact, mean SPE at Unit 5 declined when racks were blocked. Standardized passage into Sluice 3B also declined when racks were blocked, but we have little confidence in the accuracy of these split-beam estimates.

Apparent spring and summer differences in effects of blocks on sluice passage and SPE might result from differences in swimming ability of spring yearling and summer sub-yearlings smolts. Yearling fish may be able to navigate up along blocks and into surface flows whereas sub-yearlings are entrained in downward accelerating flows from 4-13.5 m of depth along trash-rack blocks. Sluice passage may be a function of the number of smolts in the 1-3 m of the water column (which is highly variable), regardless of the block treatment.

Inferences about Sluice Gate Treatments

Opening a center sluice gate significantly increased the mean FPE of Unit 5 by 35.5% (from 27.5 to 63.0%) in spring and at Unit 3 by 46% (from 30.3 to 76.9%) in summer. For Unit 3 in spring and Unit 5 in summer, respective means of 58.6 and 39.1% for the open sluice treatment were 18.6 and 10.1% higher than means for the closed sluice treatments (40 and 29%, respectively), although differences were not significant at $\alpha = 0.05$ because of high variability. Obviously, provision of a surface opening is better for smolt passage than not providing an opening, although the effect of a 0.5-2 m deep opening on more deeply distributed smolts appeared to be limited. For example, we found no significant effect of sluice-gate treatments on vertical movements of smolts sampled with split-beam acoustics. Flow vectors 6 m upstream of a sluice gate opened 2 m were downward into intake at depths > 2 m when trash racks were not blocked and downward at depths > 4.0 m when trash racks were blocked. No attraction flow would be discernable at greater depths than these for the respective treatments.

In-turbine FGE relative to traveling screens was not significantly affected by the opening or closing the sluice gate in the center intake of either unit in spring or in summer. Among intakes of both units in spring, FGE was highest for the A intake that never had an opened sluice above it. Intakes B and

C did not differ in spring. For in-turbine FGE to be affected by a sluice gate treatment, smolts would have to sense the surface flow from depths > 4 m, which is unlikely. Another explanation of how a sluice-gate treatment might affect FGE is that smolts in the upper 2-3 m of the water that might pass into an open sluice wind up passing into the turbine below as guided fish when the sluice gate is closed. However, a cursory examination of behavioral data from up-looking acoustics suggests that this explanation also is unlikely. Smolts 3 m upstream of open or closed sluice gates were moving in all directions including upstream, laterally, downstream, and up and down in the water column. A smolt unable to pass a closed sluice gate above the B intake was just as likely to move with the lateral flow toward the A intake as it was to pass into the B intake below. Lateral flow from Unit 5 toward Unit 3 also may explain higher passage at more southern intakes in spring (Figure 37), although we failed to detect such a skewed distribution of passage in summer. Perhaps sub-yearling smolts in summer were less able to avoid entrainment at the first intake they encountered than yearling smolts in spring.

The lateral distribution of smolts passing into sluice 5B was consistently skewed (two to one) toward the sides of the gate near concrete piers. Smolts may attempt to hold upstream of piers where flow into intakes is disrupted and then end up concentrated near the sides of sluice gates, or lower velocities adjacent to piers may be preferred by smolts for passage. The skewed lateral distribution into the sluice above the B intake also may have resulted from recruitment of smolts that first encountered sluice gates A and C, which were always closed. Whatever the reason, the lateral distribution within sluice gates has important implications for sampling sluice passage. For example, hydroacoustic sampling with a single up-looking transducer would underestimate passage by 50%. Adequate sampling would require more up-looking transducers to sample the lateral distribution, or the orientation of a single transducer would need to be changed from vertical to horizontal to integrate counts laterally. In 1997, the WES will examine the lateral distribution of passage into the center intake of Unit 8 to determine whether similar implications might apply to acoustic sampling of turbine passage.

Smolt Passage at Powerhouse 2

We found significant differences in total smolt passage among seasons, time of day, and intakes at Powerhouse 2. Smolt passage was higher in summer than in spring, at night than during the day, at Unit 11 than at other intakes in spring, and apparently at units on the south end of the powerhouse (11-14) than at units on the north end in summer. We found a very close correspondence between spring run timing estimated by acoustic samples and trap catches in the bypass. Correspondence also was good in summer after we excluded high passage rates from units 11-14 during the first week of summer from Powerhouse 2 averages (Figure 52). Most of the high acoustic rates at southern intakes occurred during the first week of summer immediately after river flows peaked for the year and loaded the south eddy with debris. The diel trend in total smolt passage was similar to the trend in juvenile bypass numbers of the NMFS in spring and summer, although it was highly variable among days. Sluice-chute treatments had no effect on standardized turbine passage at any intake in spring or summer.

Tests on mean fish guidance efficiency revealed significant differences among seasons, time of day, and intakes, but FGE was not affected by sluice-chute treatment. Estimates of mean FGE were higher in spring than summer and during the day than at night. Mean FGE of individual intakes ranged from about 16 to 66% in spring and from 10 to 42% in summer. In spring, mean FGE was highest at units 12 and 15 (52-65%) and lowest at Unit 11 (16%), which passed the most fish. In summer, unlike in the spring, the four units that passed the most fish also had the highest mean FGE (about 32- 42%). Sluice

chute treatments had no effect on FGE in spring or summer. Average FGE declined during summer from about 55 to about 30%. Such a decrease in FGE has been observed by other researchers (Gessel et al. 1989; Stansell et al. 1990).

Vertical Distributions and FGE

Vertical distribution data from mobile surveys often suggest that FGE should be higher than what was measured in turbine with fixed-aspect transducers. For example, the cumulative percent of smolts above 10 m of depth immediately upstream of trash racks was 73.1-76.6 in spring and 84.8-94.2 in summer at Powerhouse 1, while FGE at units 3 and 5 averaged about 55% in spring and 50% summer. At Powerhouse 2, the cumulative percent of smolts above 10 m of depth along transects 1 and 2 during the day was 93% in spring and summer whereas daytime FGE averaged 46% in spring and 32% in summer. The only time the vertical distribution data provided a reasonable explanation of FGE for Powerhouse 2 was at night in summer, when only 36% of the fish were above 10 m of depth and FGE averaged 28%. If nothing but the vertical distribution of smolts entering an intake influenced FGE, we would expect higher estimates of FGE than we measured in 1996. Either the distribution of smolts changes within 10 m of the structures where we did not sample or smolts must be avoiding screens as they enter intakes. The basis of this behavior was described in Nestler and Davidson (1995). This avoidance hypothesis could be tested by continuously sampling vertical distributions upstream of trash racks and in-turbine FGE with fixed-aspect acoustics while applying daily screen and no-screen treatments. If acoustic FGE based upon relative numbers above and below the elevation of the tip of the screen was higher for treatments without screens than for treatments with screens, avoidance would be confirmed.

Comparisons of FGE Estimates

Acoustic FGE estimates in 1996 were within 3-25% of previous FGE estimates in other years by hydroacoustics and Fyke netting for the same intake and seasons. The mean difference in 10 estimates was 10.7 ± 5% (± 95-% confidence interval), which is low considering that previous estimates were based upon daytime or early night samples as opposed to 24-hour samples. Acoustic FGE depends upon many factors including bias in the detection of fish by transducers sampling guided and unguided fish. Without intensive sampling of a single intake, it is difficult to determine the extent of bias, if any, in the 1996 estimates. Therefore, we compared 1996 estimates of FGE for the same intakes in other years by other researchers. We still need to identify biases in acoustic FGE estimates and define standards for deploying transducers, sampling, and processing to minimize them. The 1996 estimates of acoustic FGE in spring for Intake 3B averaged 66%, considerably higher than a Fyke net estimate of 41% but close to a theoretical FGE estimate of 74.3% (Gessel et al. 1989). Our average FGE estimate for Intake 3B in summer was about 46% compared to an average acoustic estimate of 32% (20-68%) by Thorne and Kuehl (1989). They sampled 7-9 hours per day for two days in late June whereas our estimate was based upon 14 days of sampling most hours each day. Fyke net sampling of Intake 3B in summer ranged from 33 to 61 percent with a mean of 41% (Gessel et al. 1989), which was reasonably close to our estimate of 46%. Our estimate of 65% FGE for Intake 12A without a TIE was close to an estimate of 70% by Gessel et al. (1988) and was higher than FGE of nearby intakes with TIES (i.e., 11A and 13C) much like Fyke-net results (Gessel et al. 1989). Acoustic and Fyke net estimates of FGE for Intake 17B in spring 1988 averaged 34 and 25%, respectively (Magne et al. 1989), compared to our estimate of 39% in 1996. Our estimates of FGE for intake 11A during the day in spring (17%) and summer (8%) were low compared to acoustic

estimates of 33 and 20% for the same intake and season in 1988 (Stansell et al. 1990). Our estimates included samples after 2300 hours and through the night when FGE usually is lower than during the day whereas the 1988 samples were taken from 0900-2300 hours only. For intake 18A, our estimates for spring and summer (31 and 15%, respectively) probably do not differ significantly from estimates of 22 and 13% taken in 1988 (Stansell et al. 1990).

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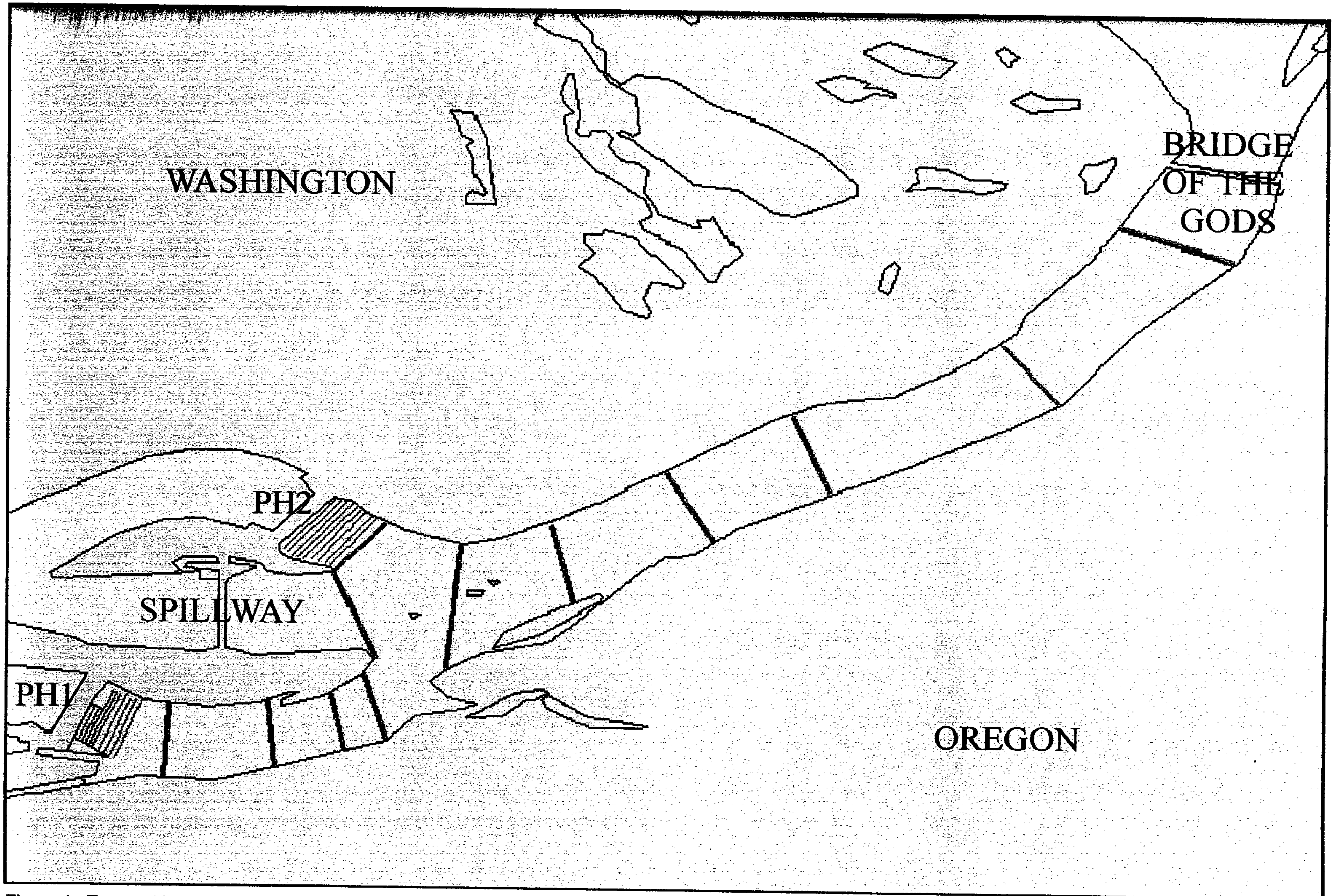


Figure 1. Transect locations between Bonneville Dam and Bridge of the Gods for mobile surveys in 1996.

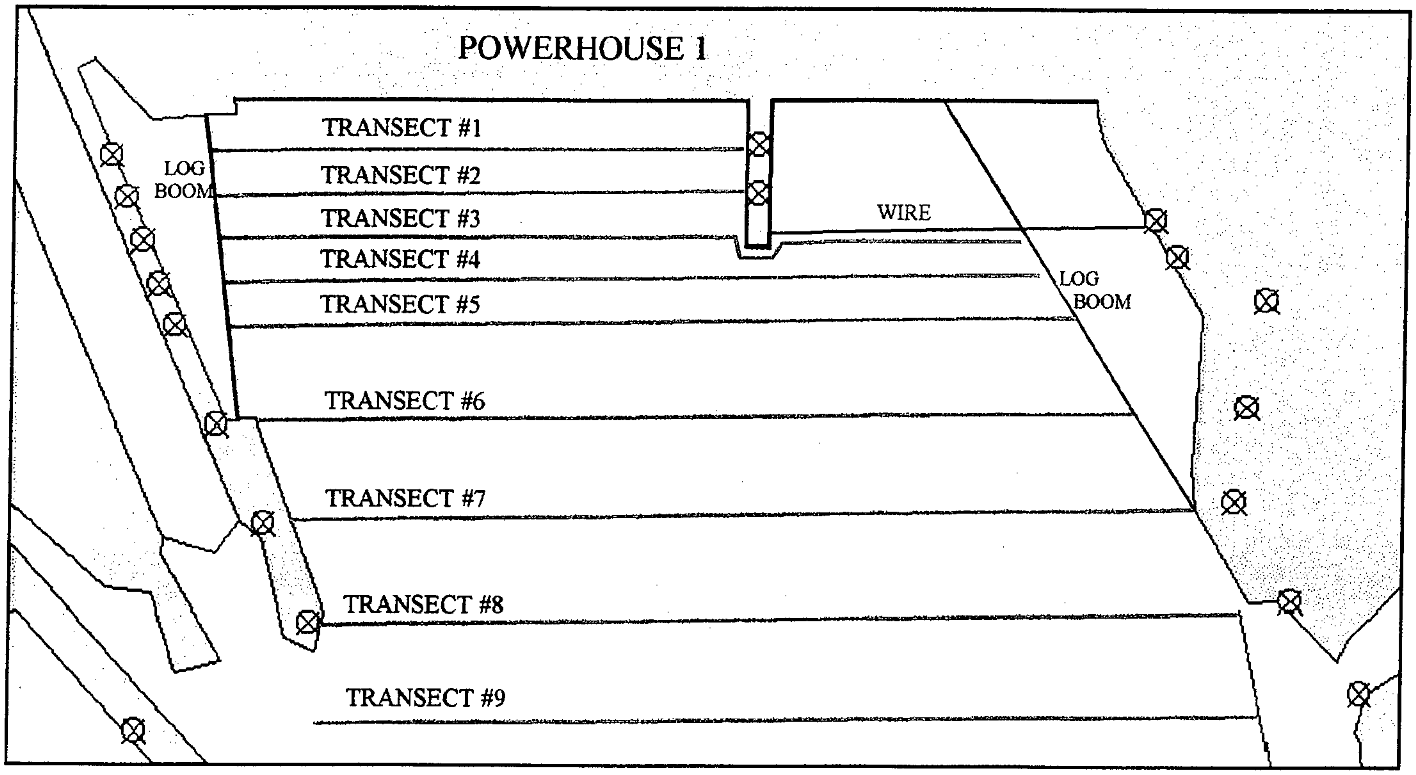
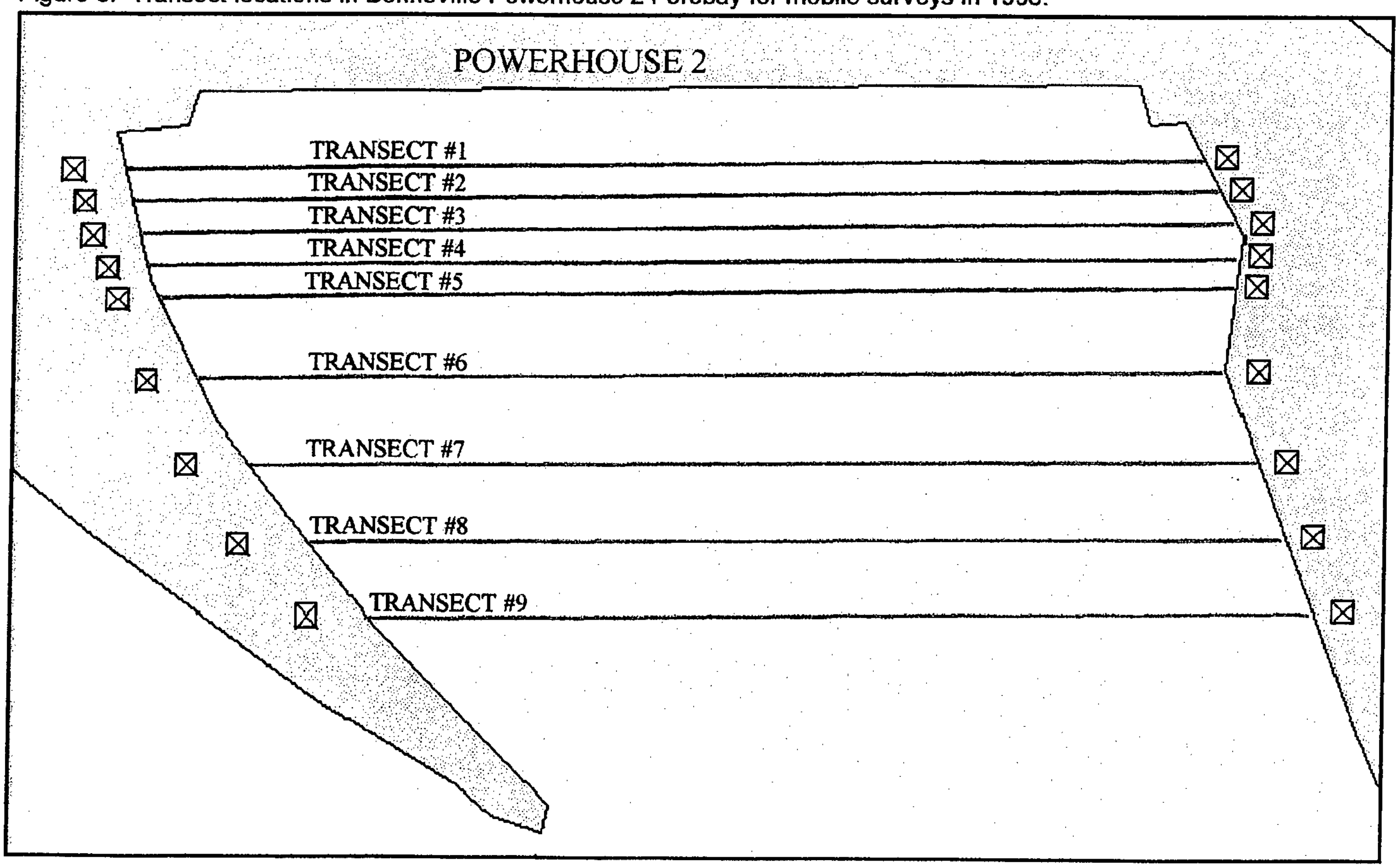


Figure 2. Transect locations in Bonneville Powerhouse 1 Forebay for mobile surveys in 1996.

Figure 3. Transect locations in Bonneville Powerhouse 2 Forebay for mobile surveys in 1996.



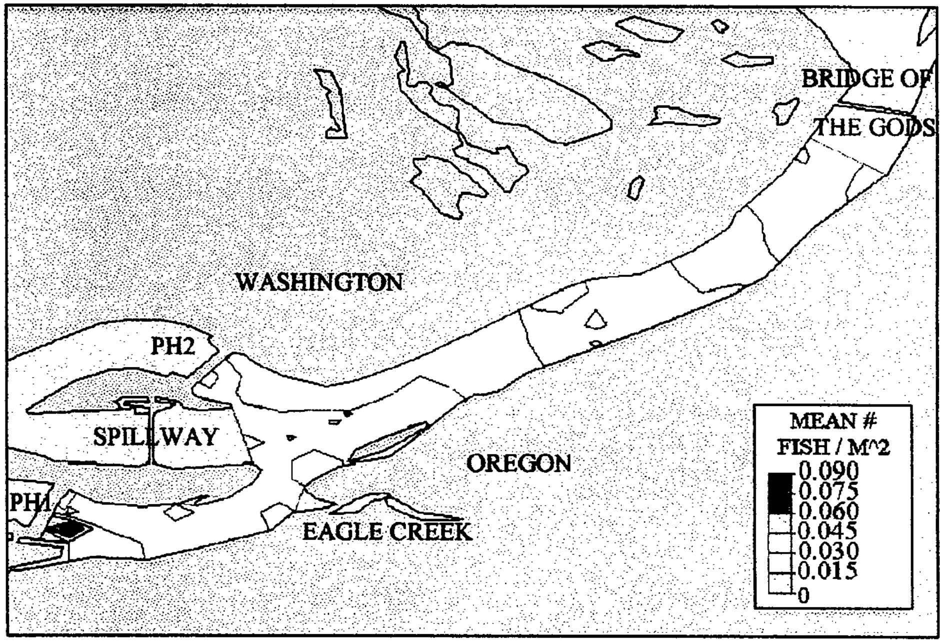


Figure 4. Mean horizontal interpolation of fish densities between transects from Bonneville Dam to Bridge of the Gods surveyed during the day in spring 1996.

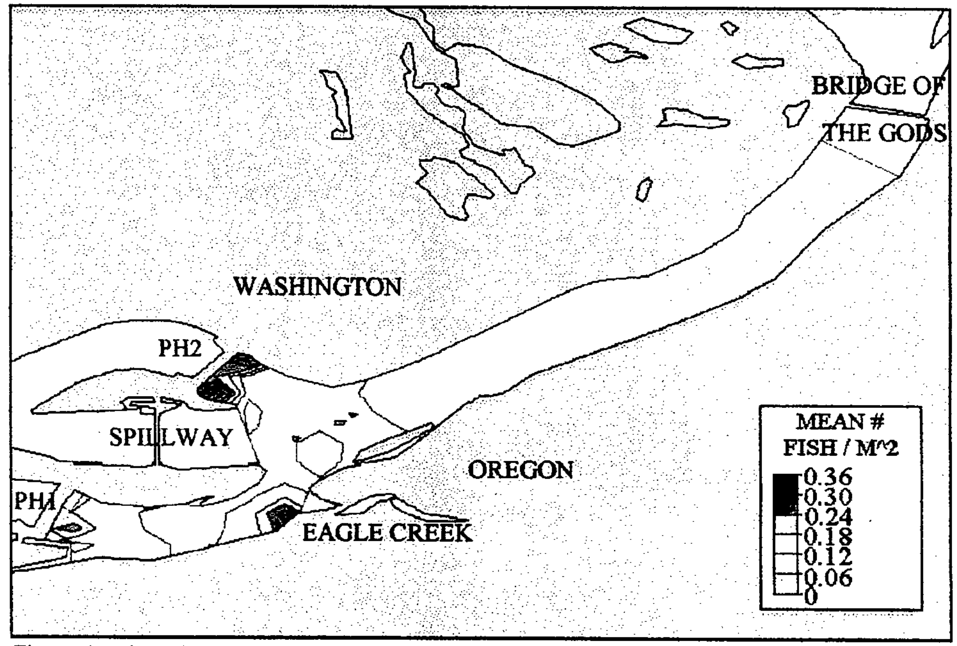


Figure 6. Mean horizontal interpolation of fish densities between transects from Bonneville Dam to Bridge of the Gods surveyed during the day in summer 1996.

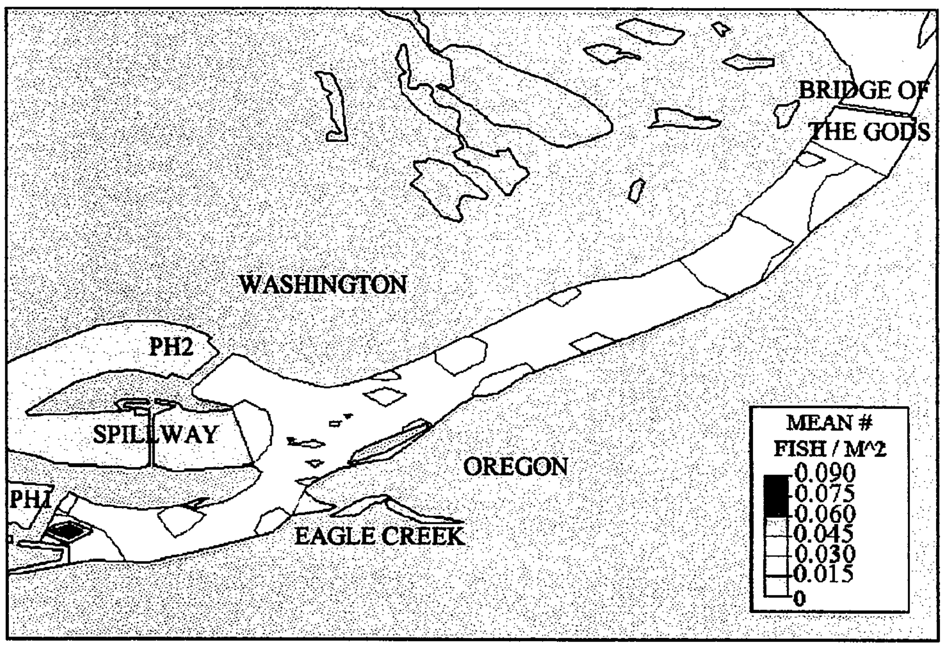


Figure 5. Mean horizontal interpolation of fish densities between transects from Bonneville Dam to Bridge of the Gods surveyed at night in spring 1996.

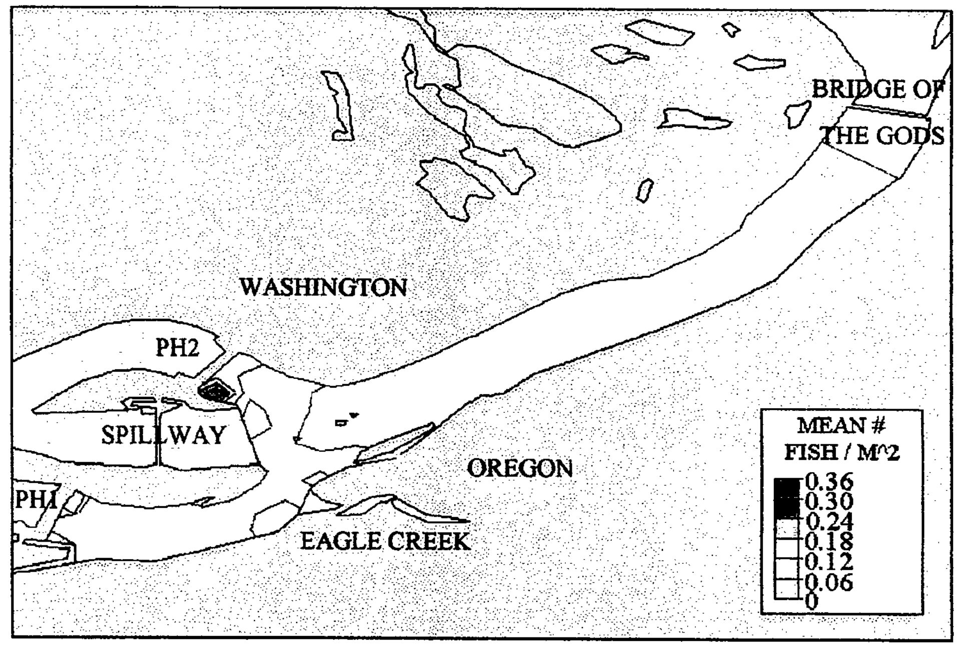


Figure 7. Mean horizontal interpolation of fish densities between transects from Bonneville Dam to Bridge of the Gods surveyed at night in summer 1996.

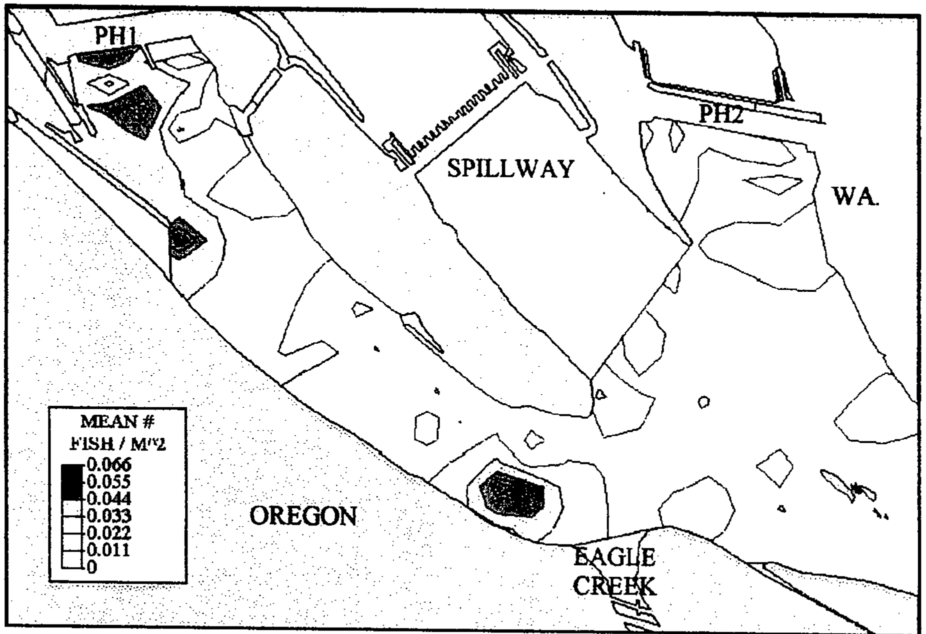


Figure 8. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse Forebays surveyed during the day in spring 1996.

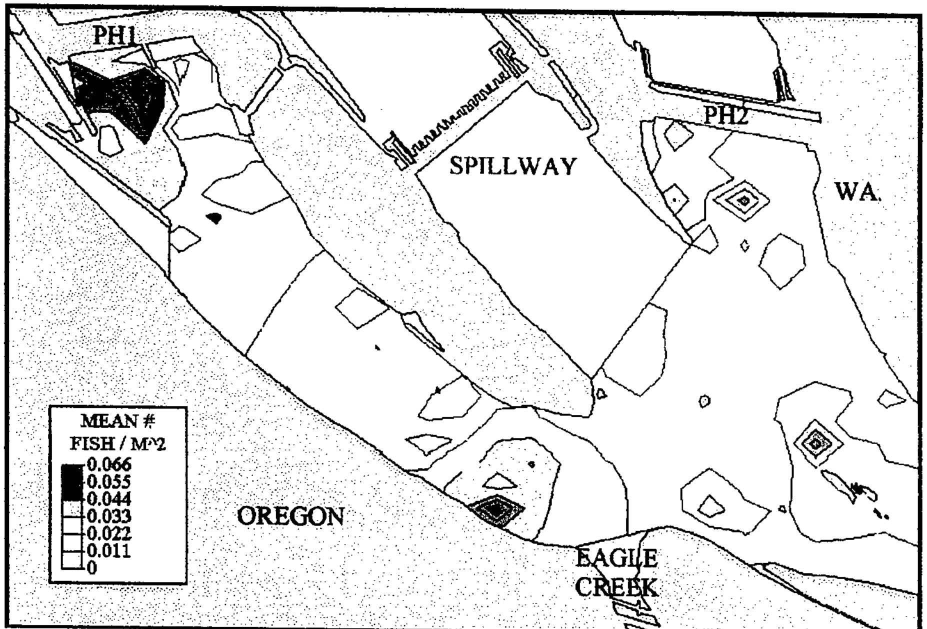


Figure 9. Mean horizontal interpolation of fish densities between transects in Bonneville Dam Forebays surveyed at night in spring 1996.

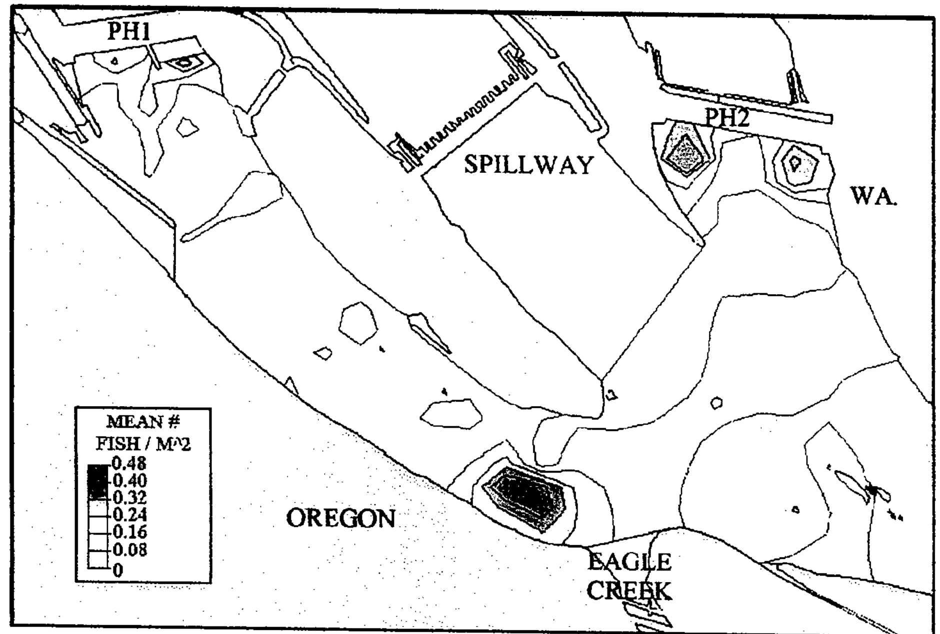


Figure 10. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse Forebays surveyed during the day in summer 1996.

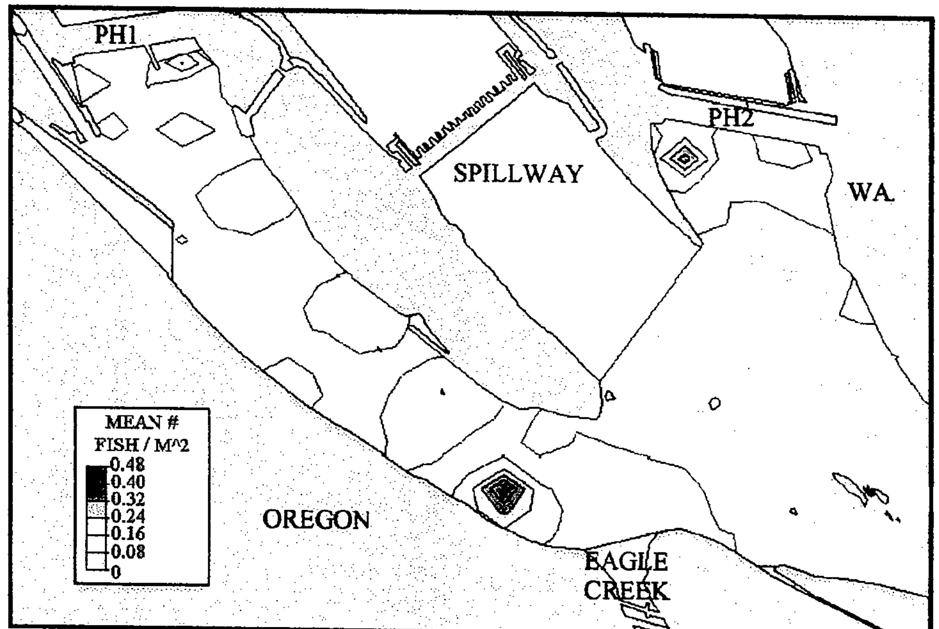


Figure 11. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse Forebays surveyed at night in summer 1996.

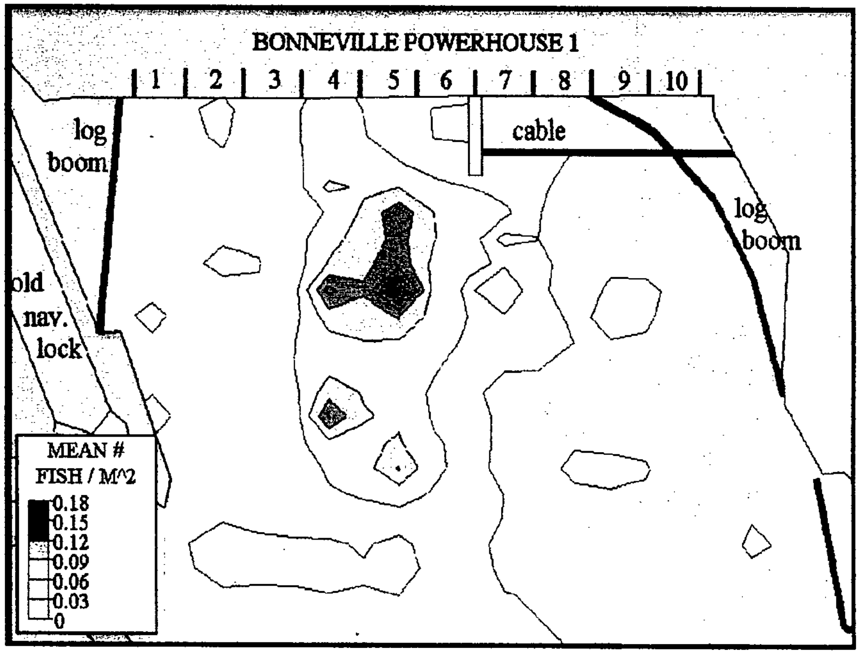


Figure 12. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse 1 Forebay surveyed during the day in spring 1996.

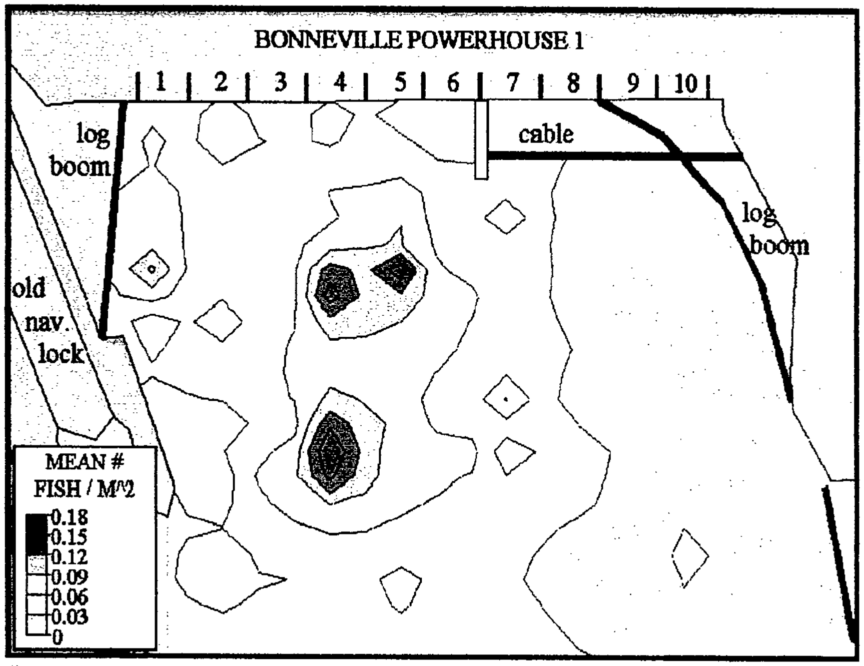


Figure 13. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse 1 Forebay surveyed at night in spring 1996.

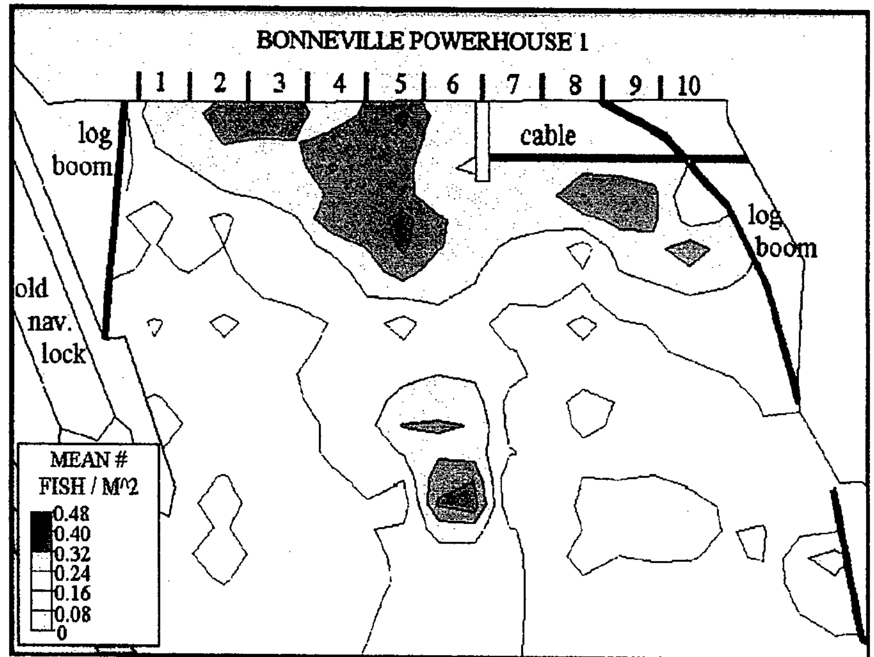


Figure 14. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse 1 Forebay surveyed during the day in summer 1996.

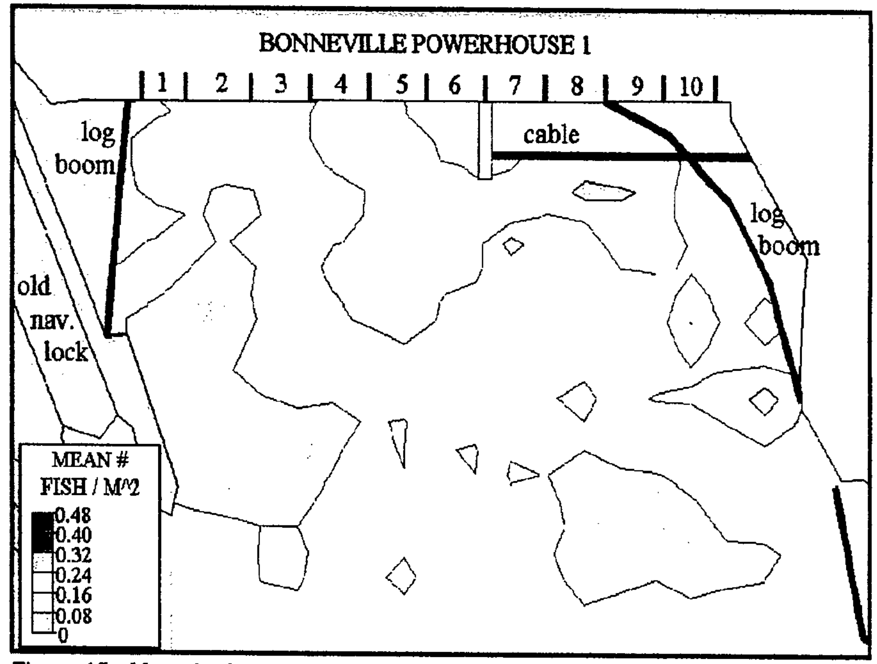


Figure 15. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse 1 Forebay surveyed at night in summer 1996.

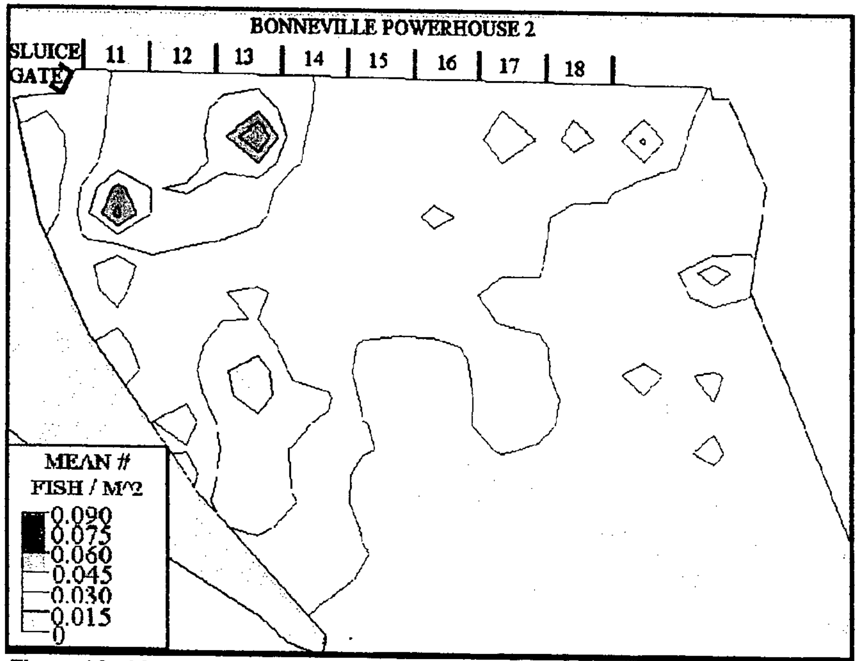


Figure 16. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse 2 Forebay surveyed during the day in spring 1996.

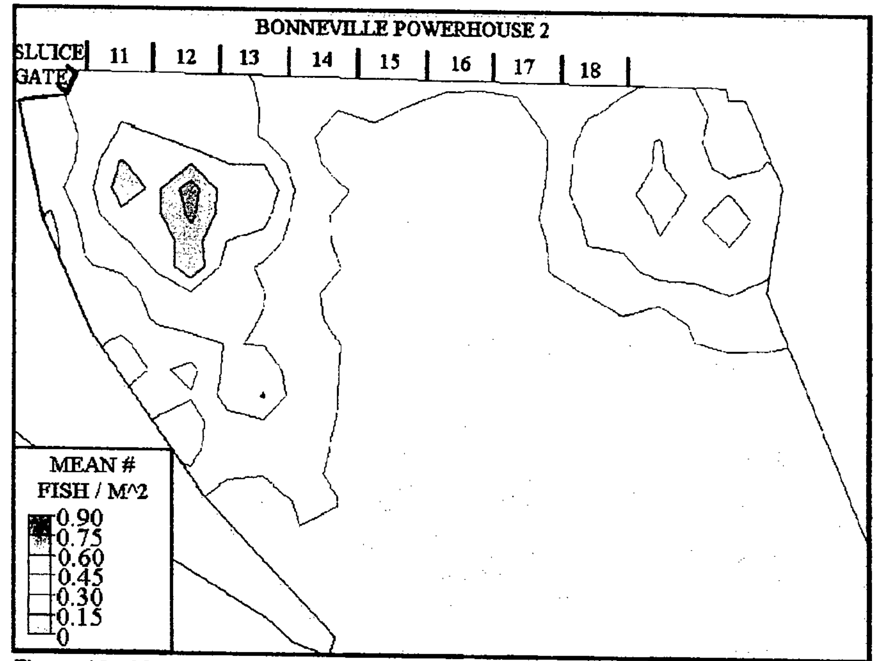


Figure 18. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse 2 Forebay surveyed during the day in summer 1996.

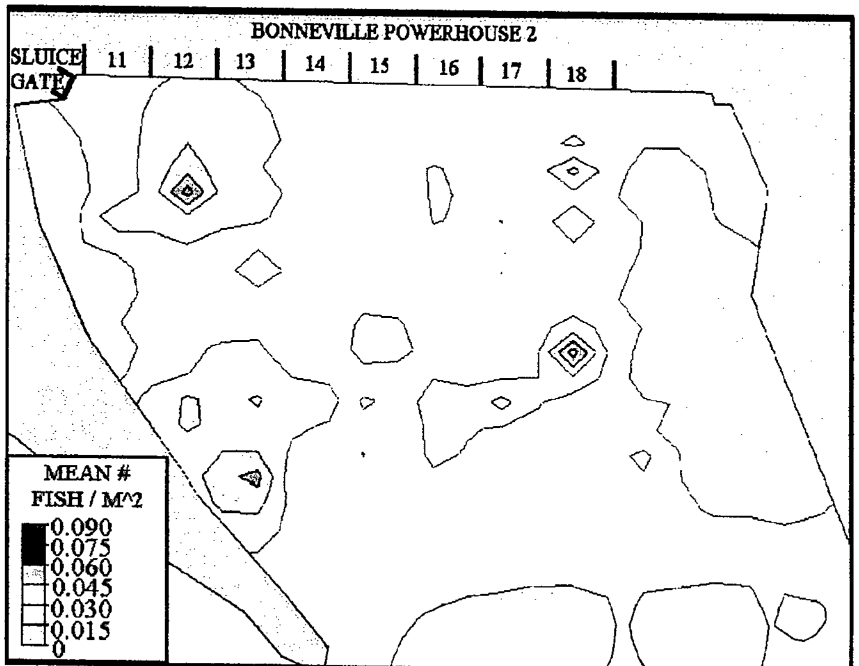


Figure 17. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse 2 Forebay surveyed at night in spring 1996.

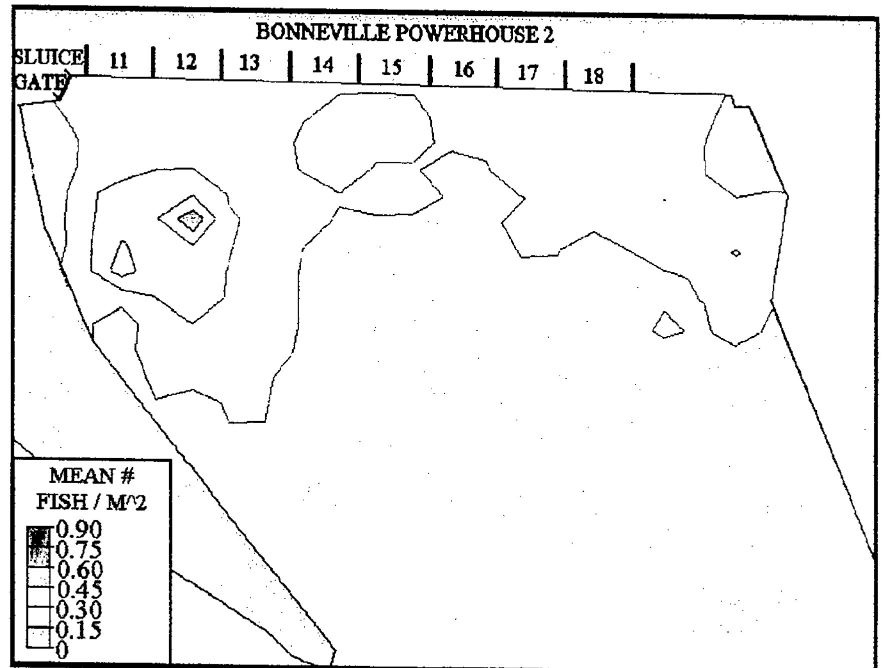


Figure 19. Mean horizontal interpolation of fish densities between transects in Bonneville Powerhouse 2 Forebay surveyed at night in summer 1996.

Figure 20. Spring daytime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute open.
Column 1 = Transect 1; Column 2 = Transect 2.
Row 1 = 05/08/96; Row 2 = 05/12/96; Row 3 = 05/18/96.
Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.

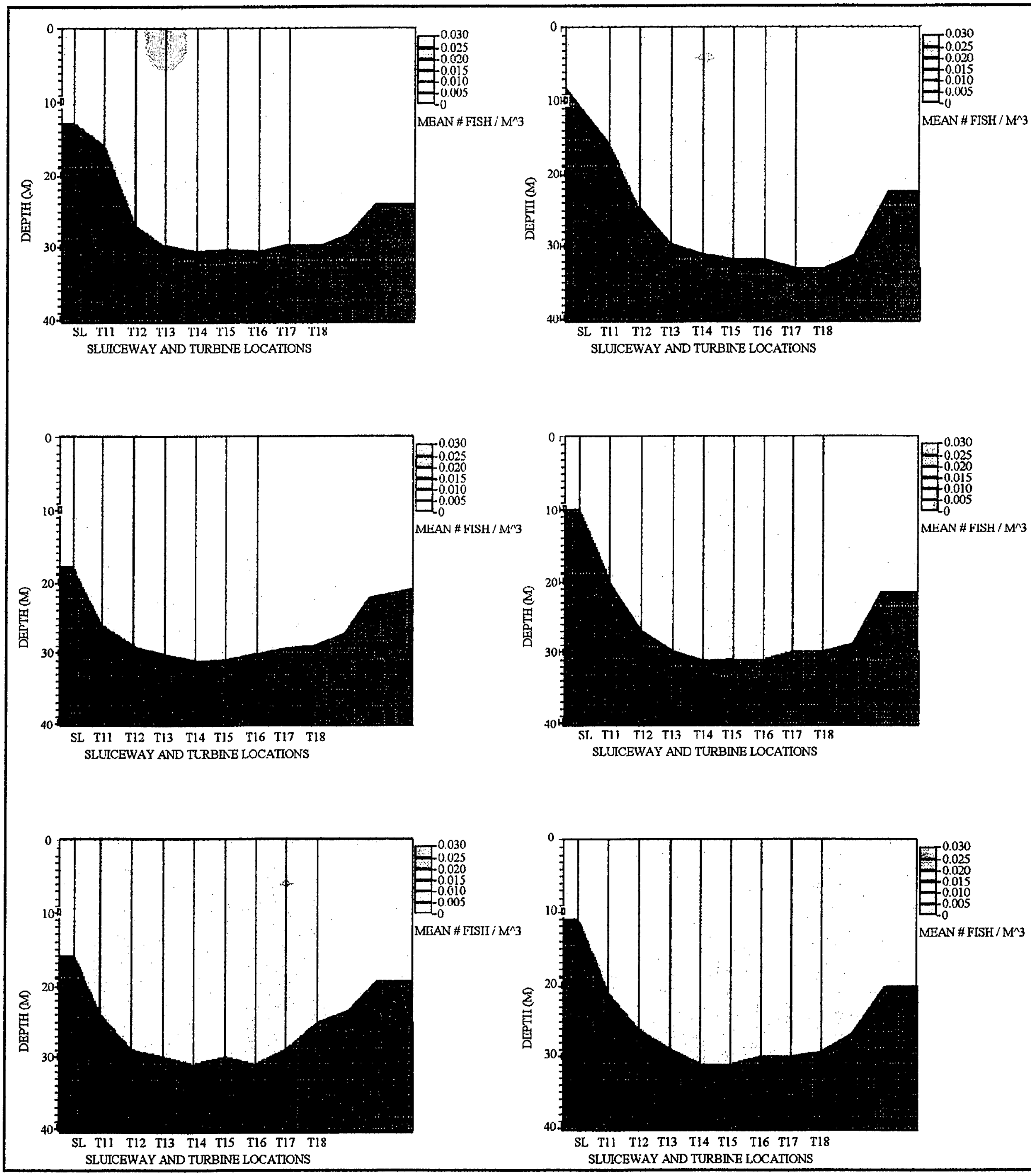


Figure 21. Spring daytime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute closed.
Column 1 = Transect 1; Column 2 = Transect 2. Row 1 = 04/30/96; Row 2 = 05/04/96; Row 3 = 05/15/96.
Orientation is facing the dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.

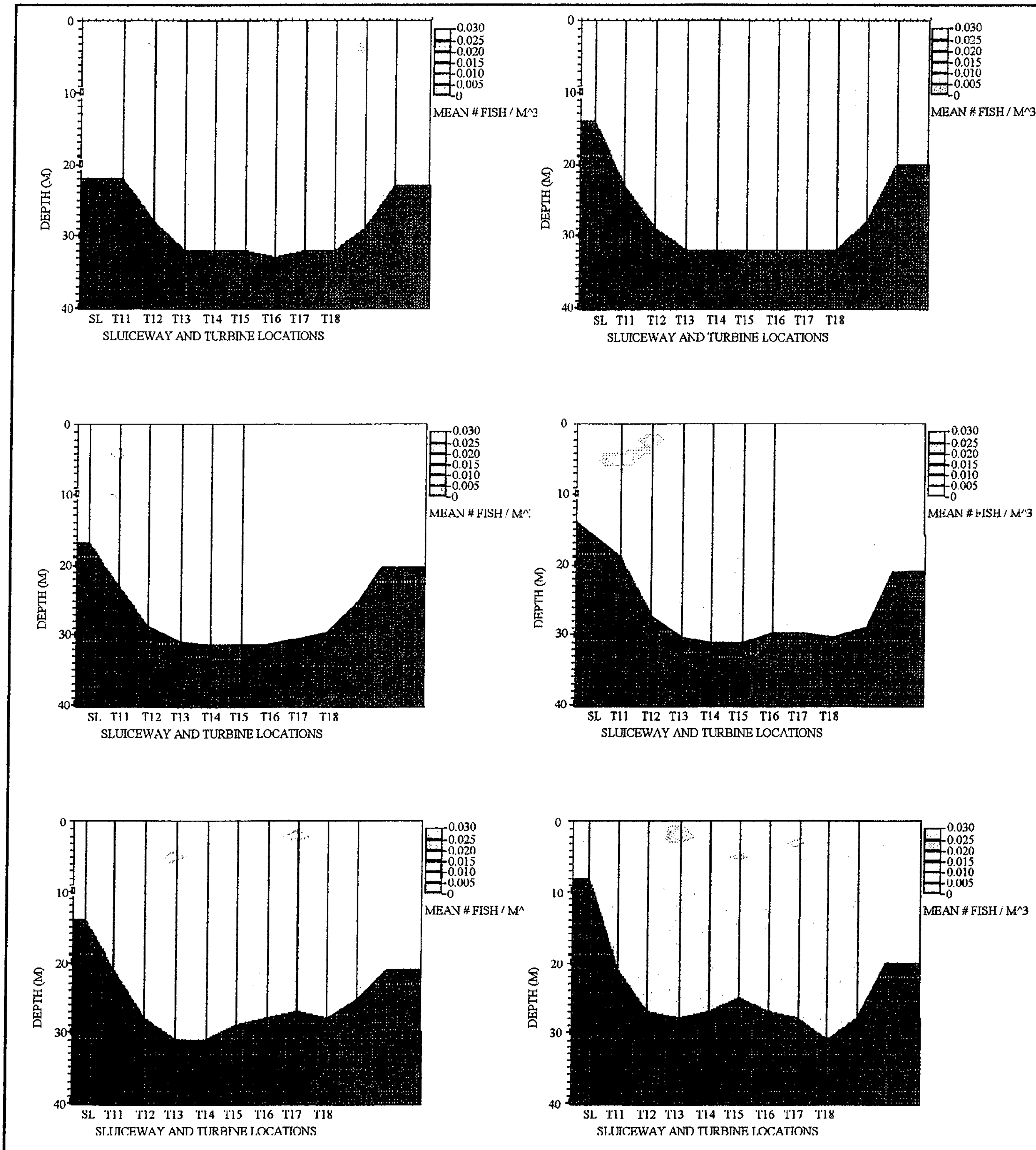


Figure 22. Spring nighttime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute open.
Column 1 = Transect 1; Column 2 = Transect2.
Row 1 = 05/08/96; Row 2 = 05/12/96; Row 3 = 05/18/96.
Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.

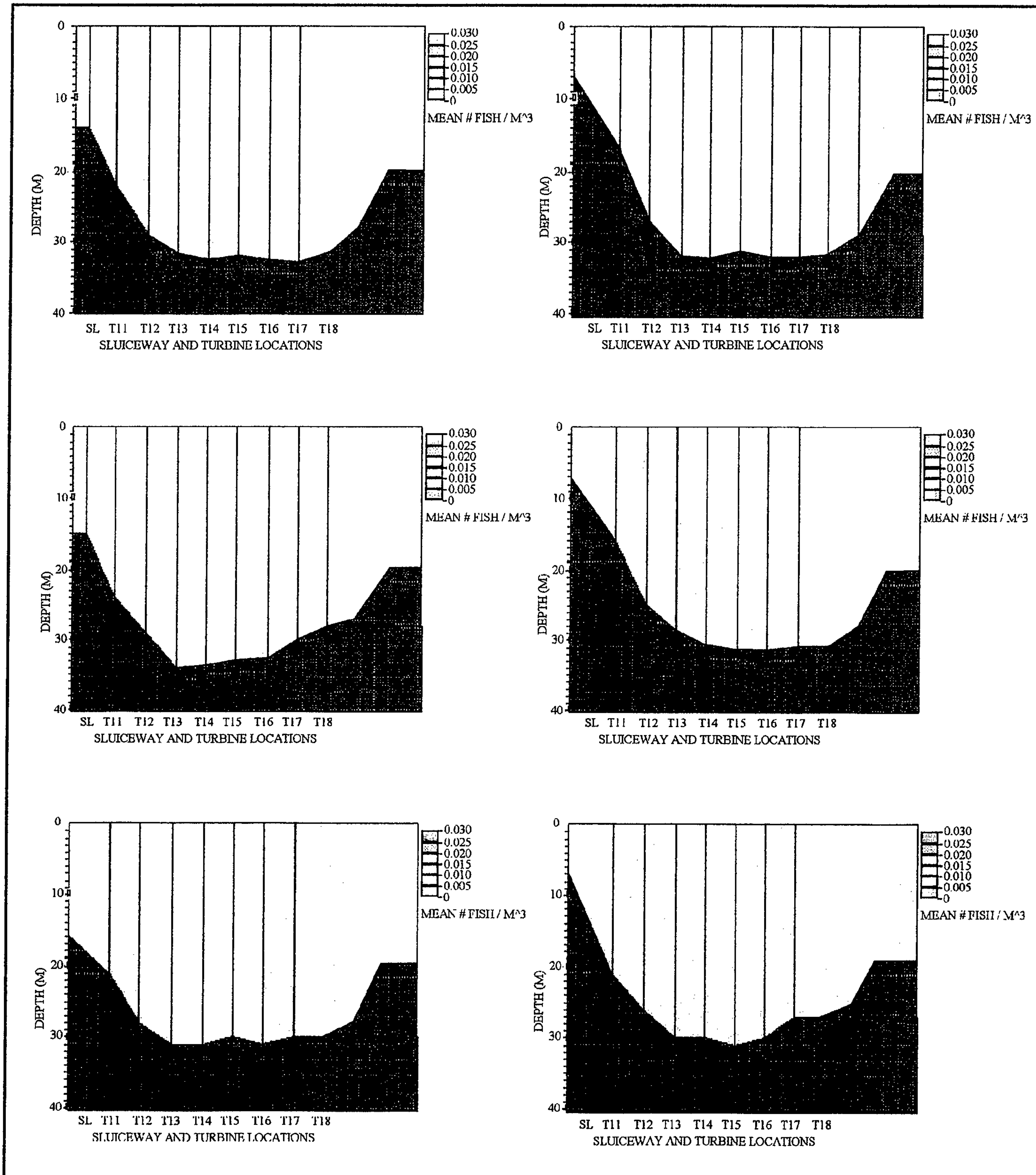


Figure 23. Spring nighttime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute closed.
Column 1 = Transect 1; Column 2 = Transect 2.
Row 1 = 04/30/96; Row 2 = 05/04/96; Row 3 = 05/15/96.
Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.

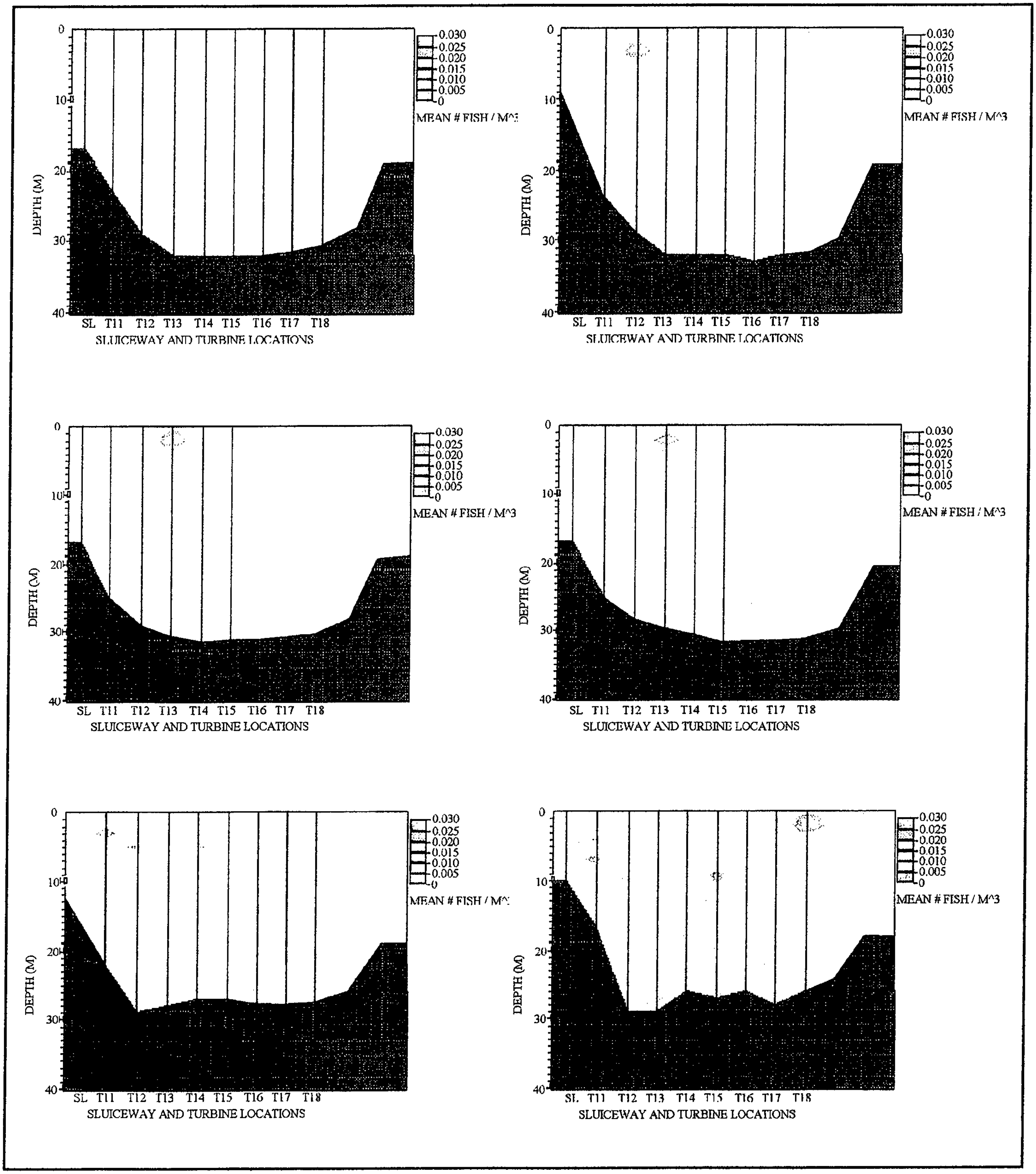


Figure 24. Summer daytime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute open.
Column 1 = Transect 1; Column 2 = Transect 2. Row 1 = 06/29/96; Row 2 = 06/30/96; Row 3 = 07/03/96.
Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.

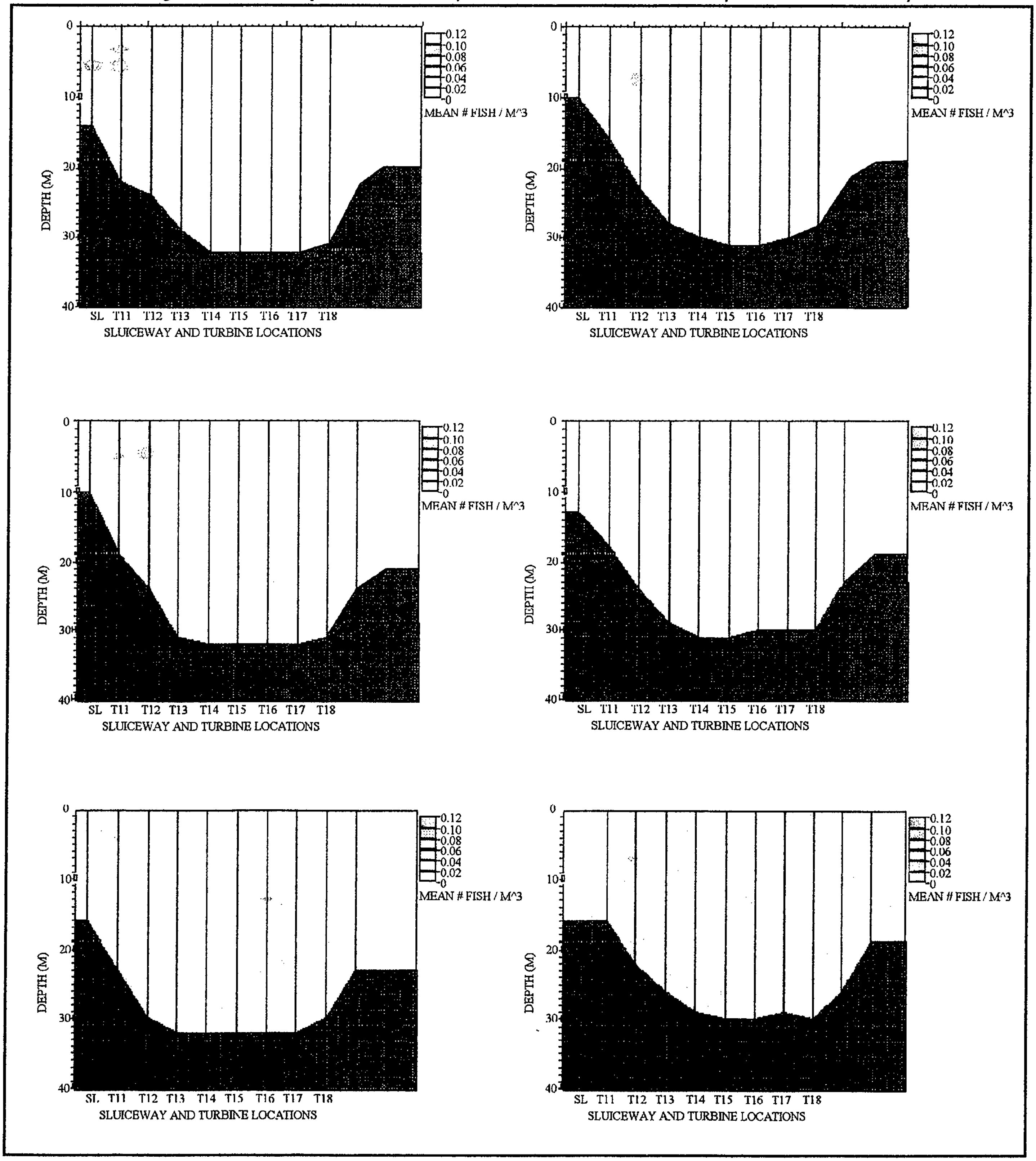


Figure 25. Summer daytime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice shute closed. Column 1 = Transect 1; Column 2 = Transect 2.
Row 1 = 07/07/96; Row 2 = 07/09/96*first survey; Row 3 = 07/09/96*second survey.
Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.

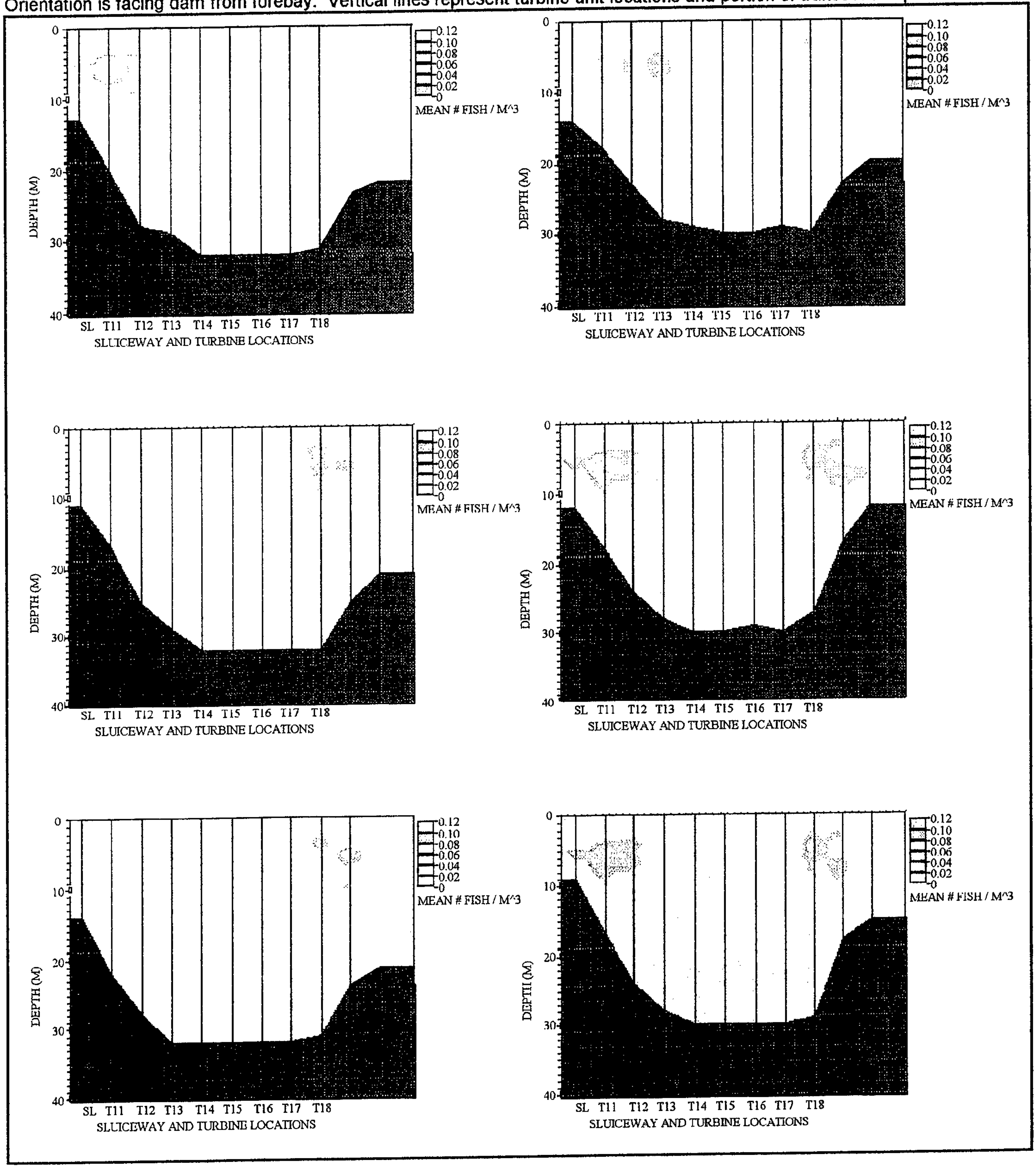


Figure 26. Summer nighttime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute open.
Column 1 = Transect 1; Column 2 = Transect 2. Row 1 = 06/29/96; Row 2 = 06/30/96; Row 3 = 07/03/96;
Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.

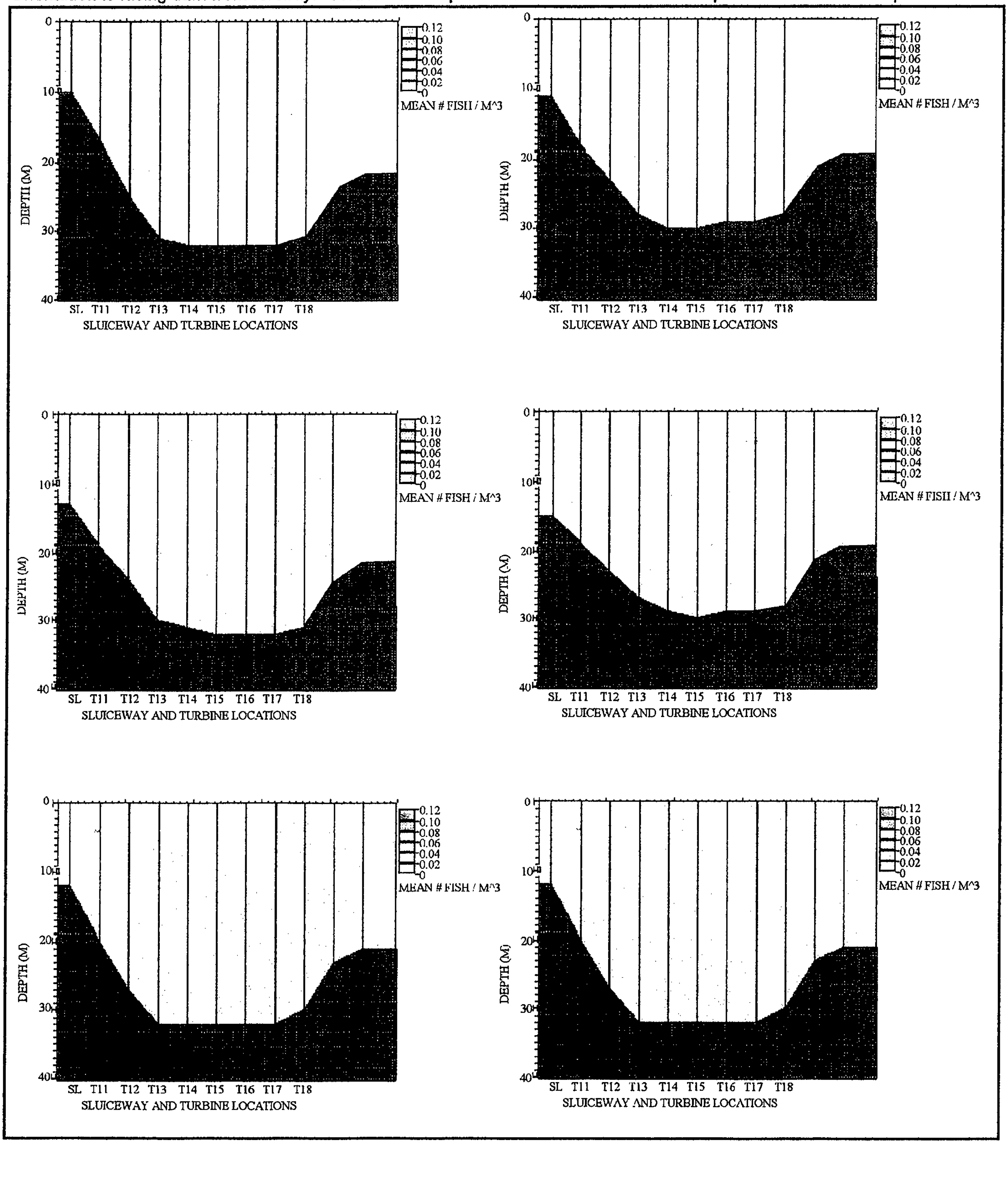
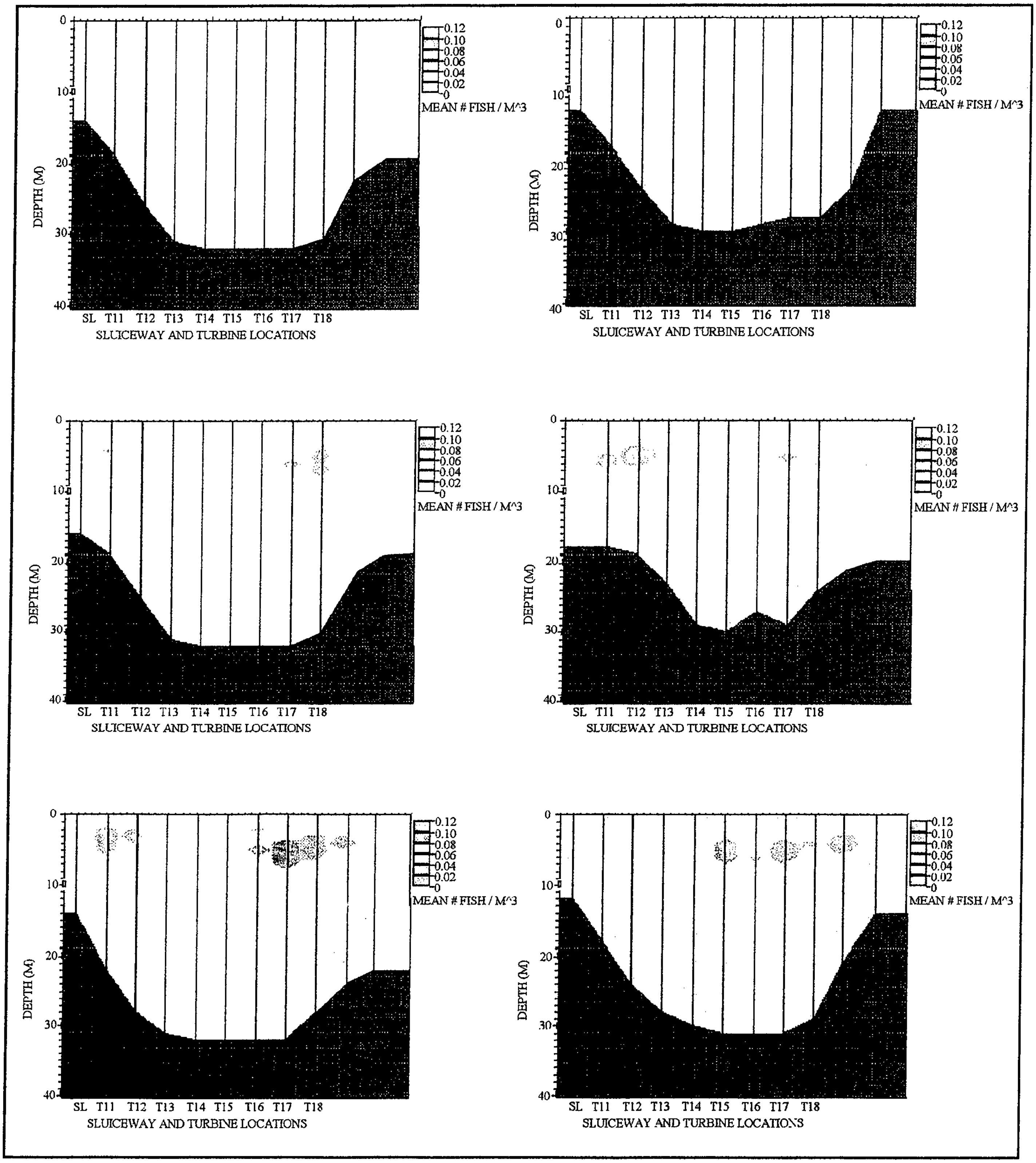
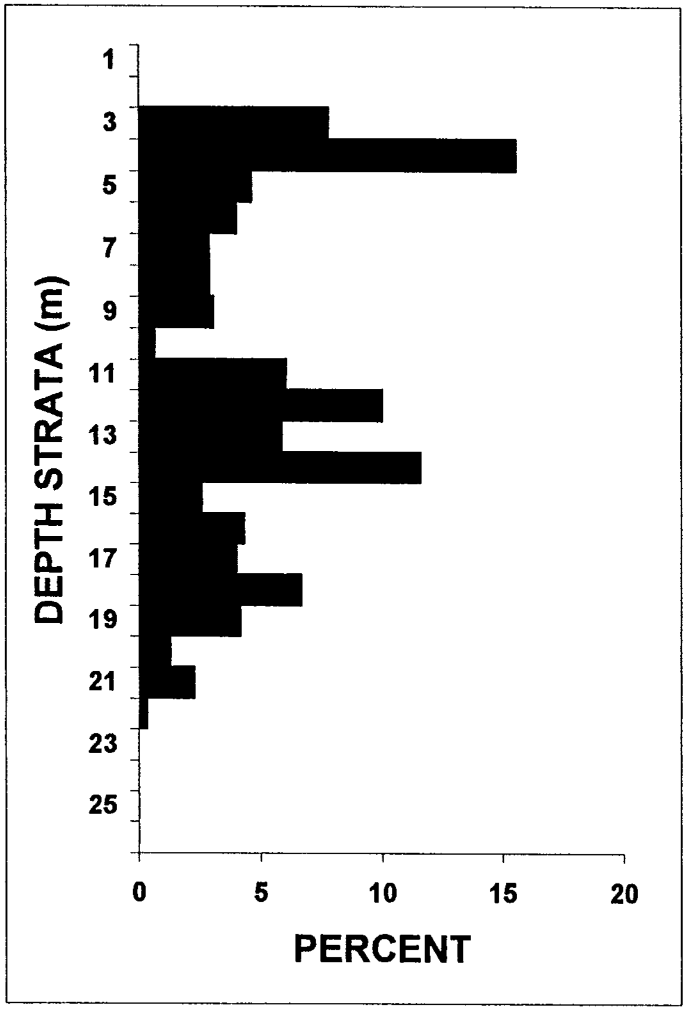
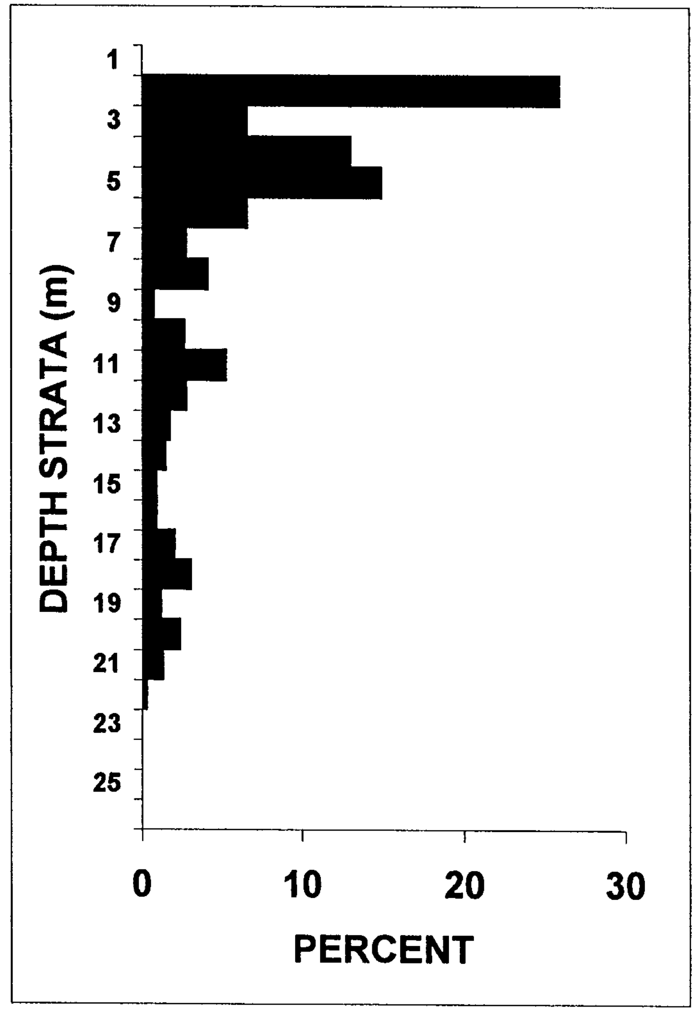


Figure 27. Summer nighttime vertical interpolation of fish densities for transects 1 and 2 at Bonneville Powerhouse 2; sluice chute closed.
Column 1 = Transect 1; Column 2 = Transect 2. Row 1 = 06/27/96; Row 2 = 07/07/96; Row 3 = 07/09/96.
Orientation is facing dam from forebay. Vertical lines represent turbine unit locations and portion of transect sampled.



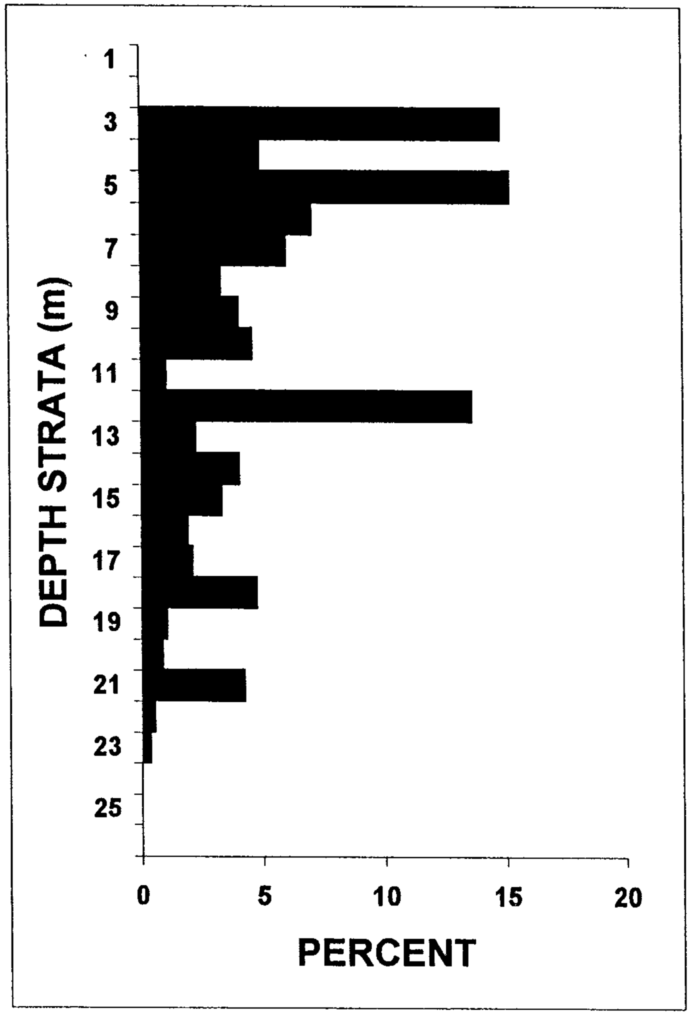


0
7.77
23.3
27.89
31.85
34.71
37.56
40.57
41.2
47.23
57.21
63.07
74.64
77.18
81.46
85.42
92.08
96.2
97.46
99.68
100
100
100
100
100

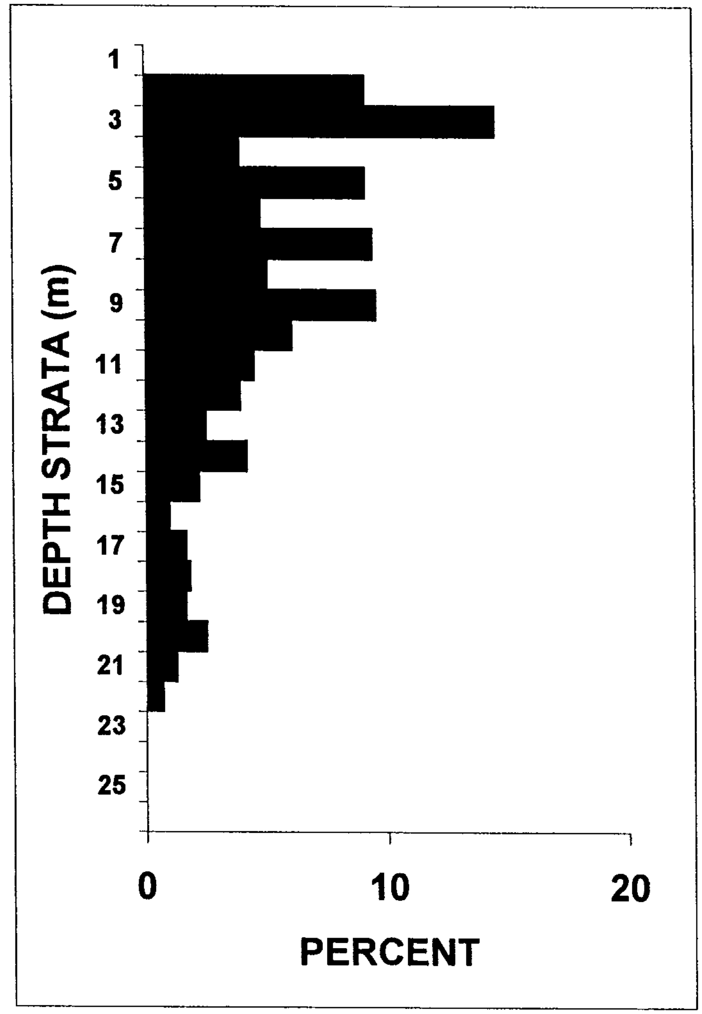


25.9
32.42
45.44
60.35
66.86
69.61
73.66
74.38
76.99
82.2
84.95
86.69
88.13
89
89.87
91.9
94.93
96.09
98.41
99.71
100
100
100
100
100

Figure 28. Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 1 (left graph) and within 20-30 m of the powerhouse (right graph) during the day in spring.

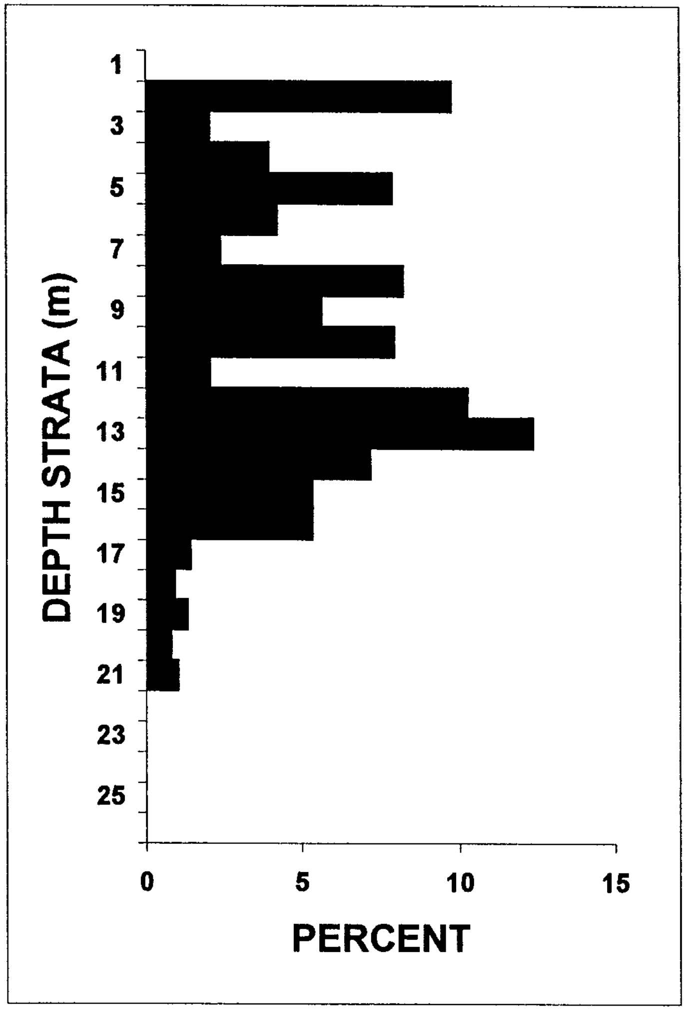


0
14.79
19.72
34.86
41.9
47.89
51.23
55.28
59.86
60.92
74.47
76.76
80.81
84.15
86.09
88.2
92.96
94.01
94.89
99.12
99.65
100
100
100
100

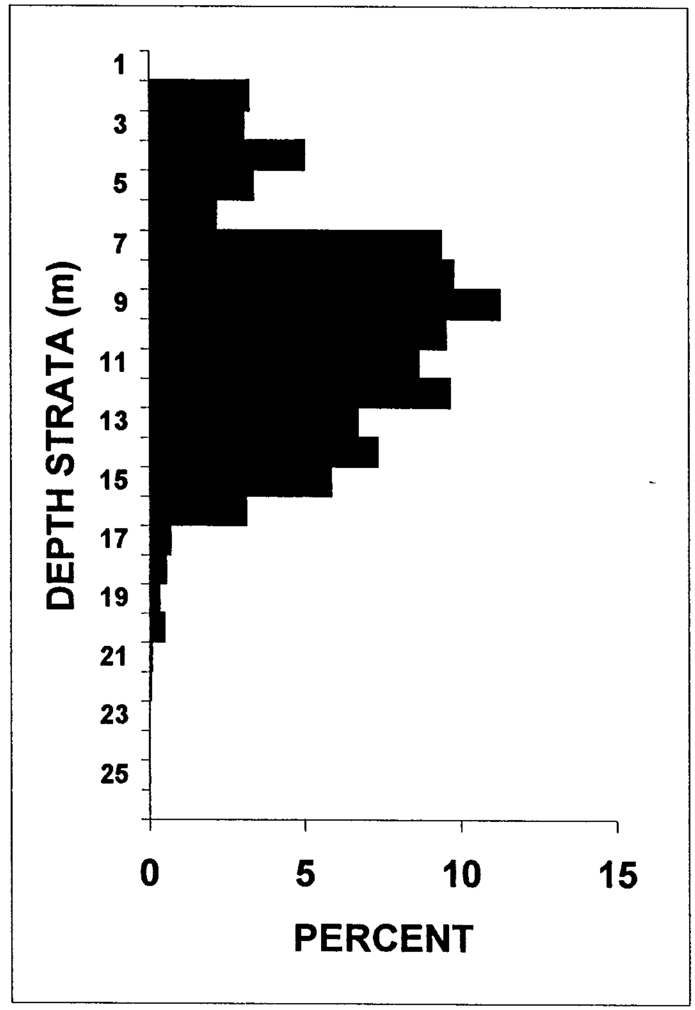


9.09
23.58
27.56
36.65
41.48
50.85
55.97
65.48
71.59
76.14
80.11
82.67
86.93
89.2
90.2
91.9
93.75
95.45
98.01
99.29
100
100
100
100
100

Figure 29. Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 1 (left graph) and within 20-30 m of the powerhouse (right graph) at night in spring.



9.75
11.81
15.77
23.62
27.87
30.28
38.47
44.09
52.01
54.07
64.33
76.66
83.83
89.16
94.5
95.93
96.85
98.17
98.97
100
100
100
100
100
100



3.21
6.27
11.27
14.65
16.82
26.2
35.97
47.19
56.71
65.36
75
81.69
89
94.83
97.95
98.62
99.14
99.46
99.9
99.97
100
100
100
100
100

Figure 30. Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 1 (left graph) and within 20-30 m of the powerhouse (right graph) during the day in summer.

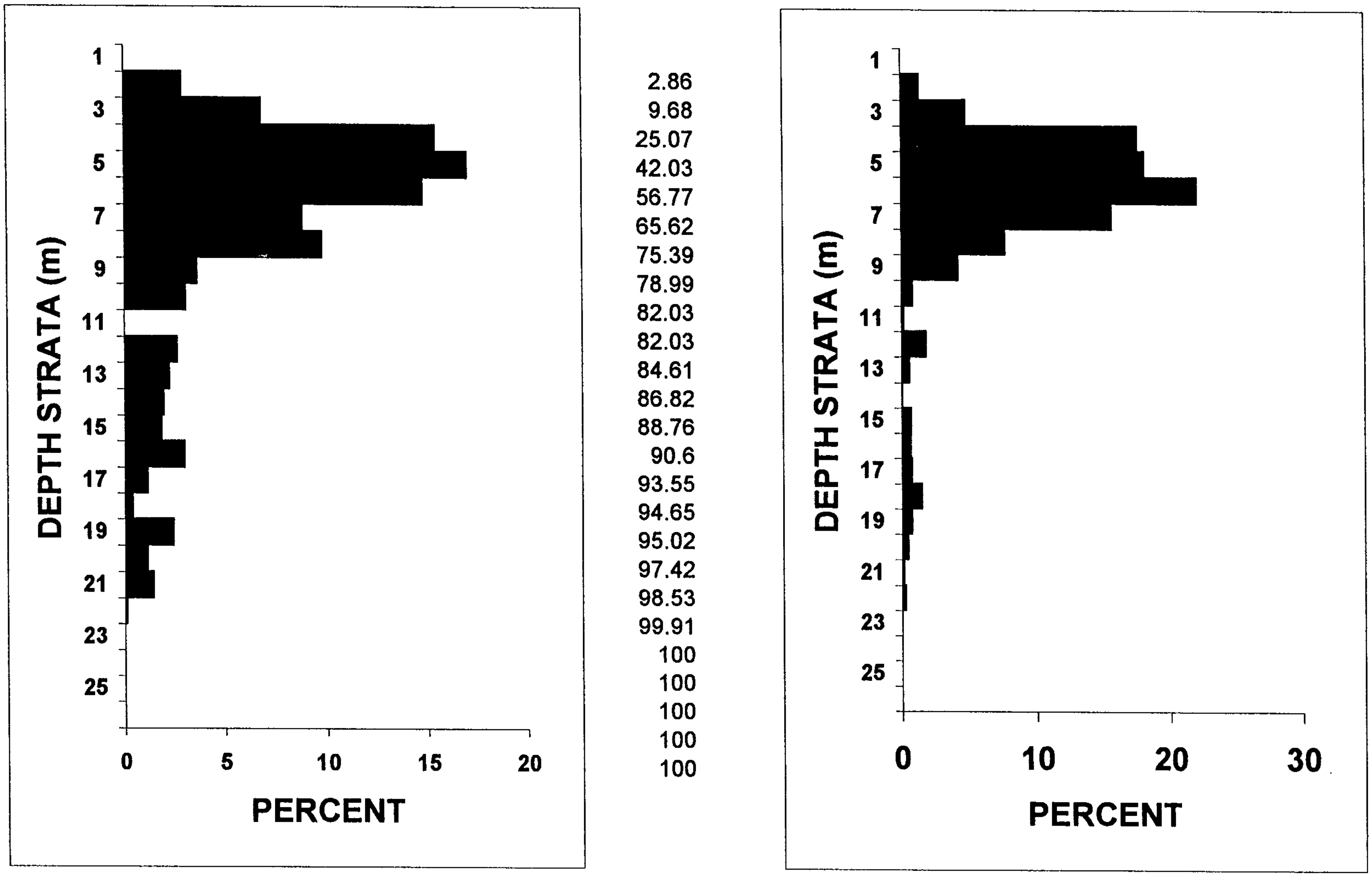
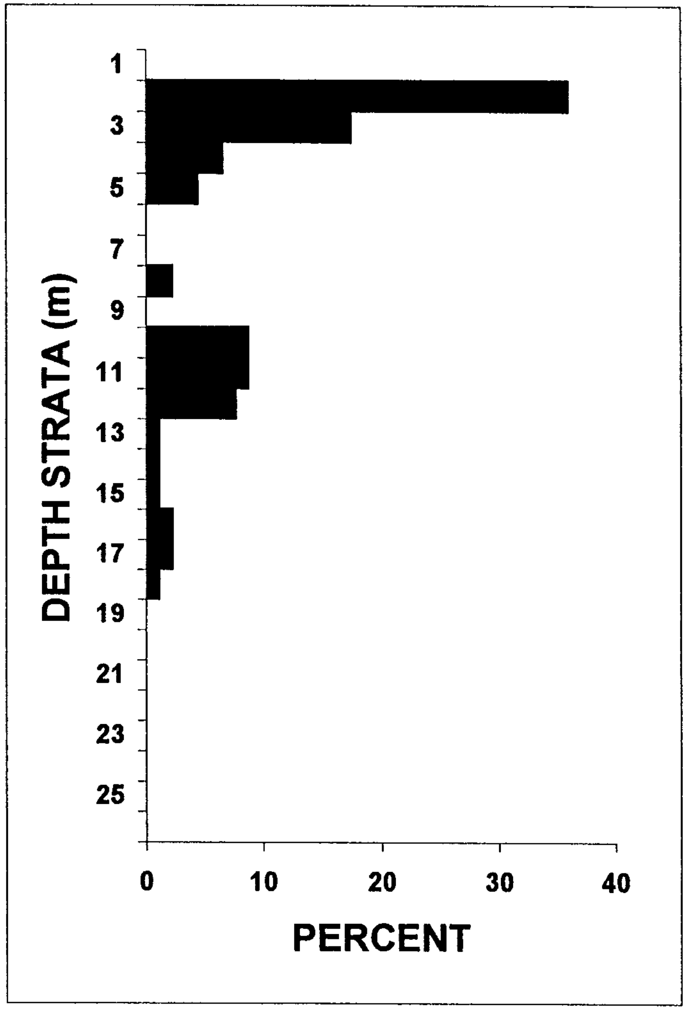
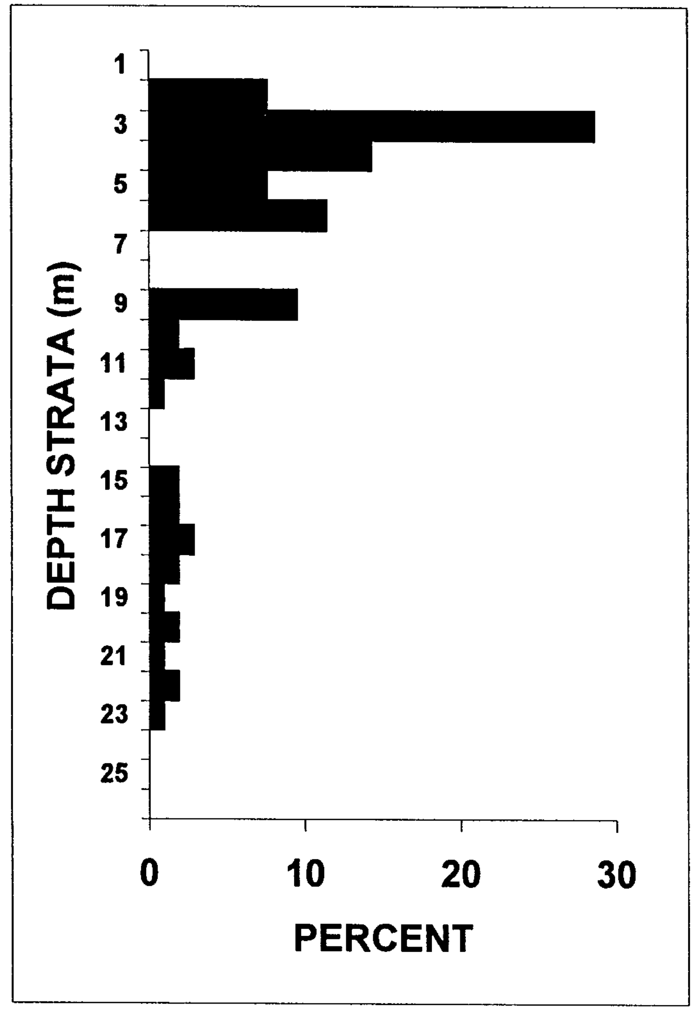


Figure 31. Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 1 (left graph) and within 20-30 m of the powerhouse (right graph) at night in summer.



35.87
53.26
59.78
64.13
64.13
64.13
66.3
66.3
75
83.7
91.3
92.39
93.48
94.57
96.74
98.91
100
100
100
100
100
100
100
100
100



7.62
36.19
50.48
58.1
69.52
69.52
69.52
79.05
80.95
83.81
84.76
84.76
84.76
86.67
88.57
91.43
93.33
94.29
96.19
97.14
99.05
100
100
100
100

Figure 32. Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 2 (left graph) and within 20-30 m of the powerhouse (right graph) during the day in spring.

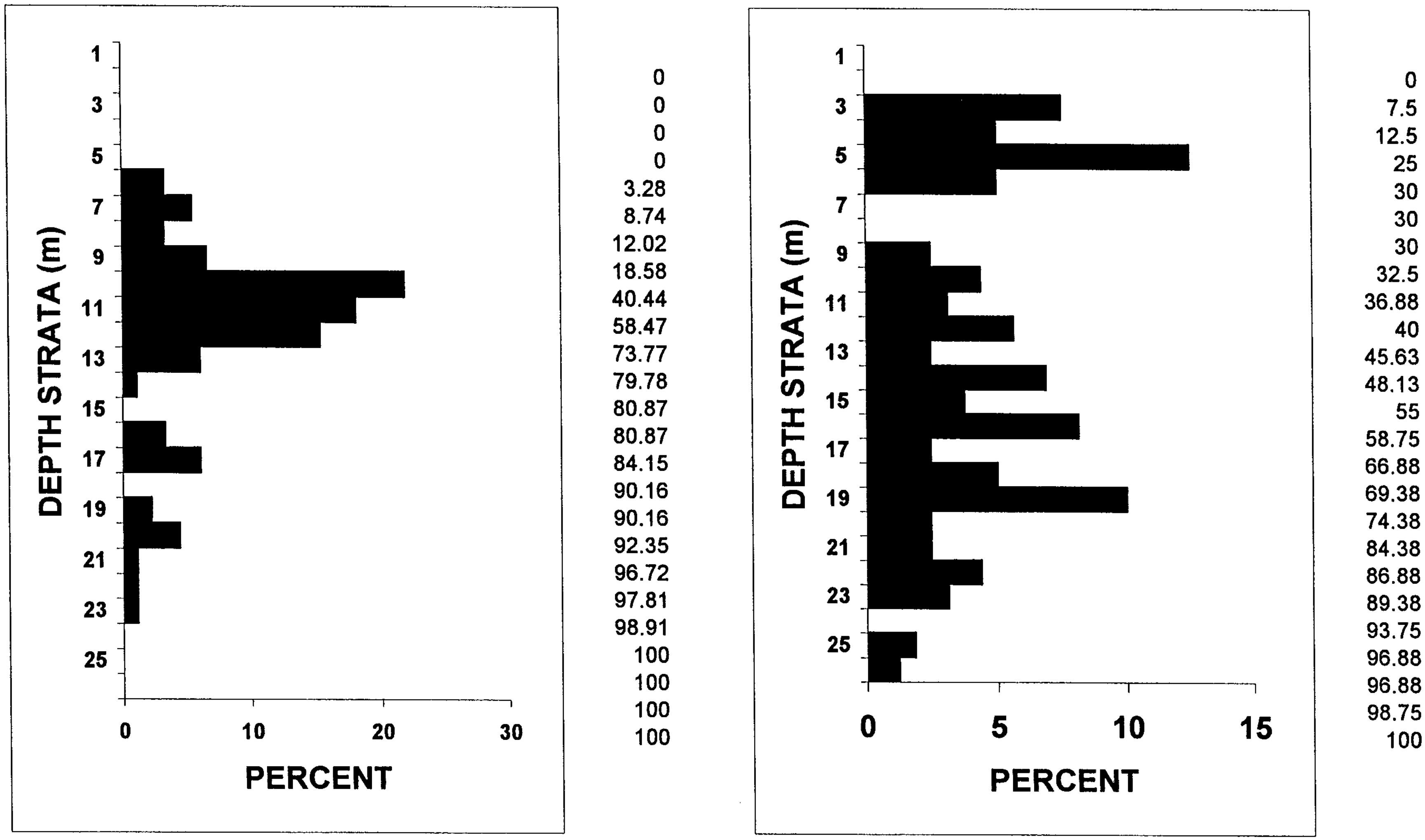
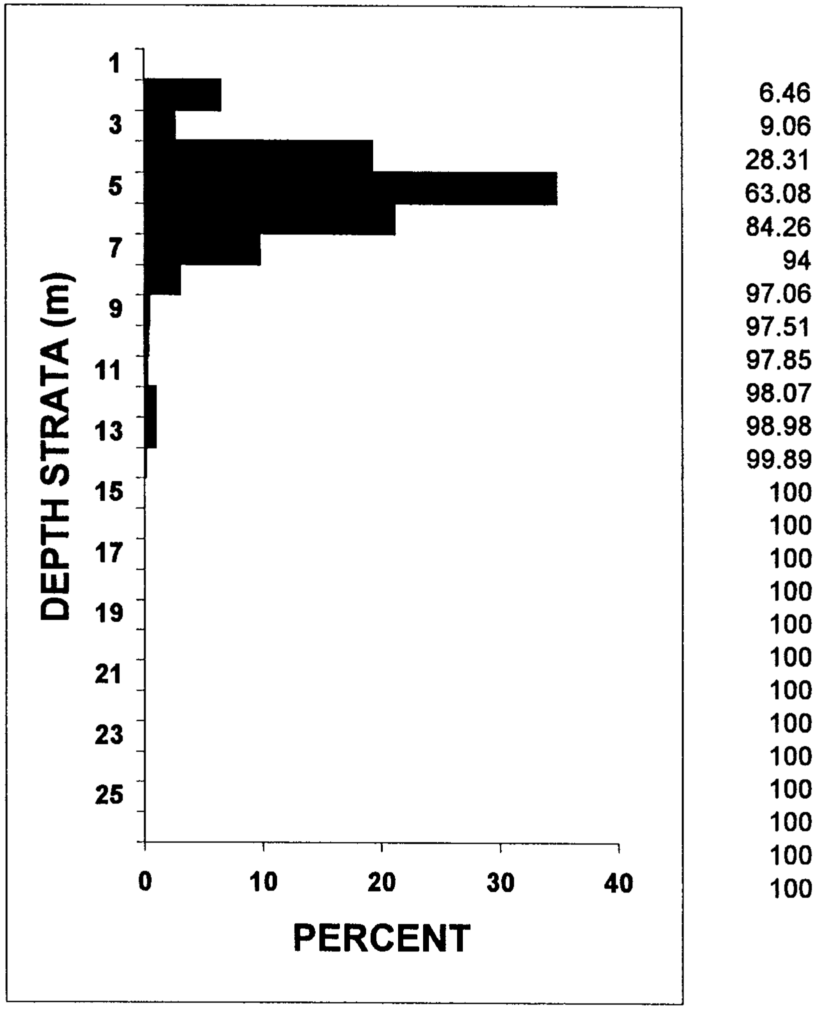


Figure 33. Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 2 (left graph) and within 20-30 m of the powerhouse (right graph) dat night in spring.



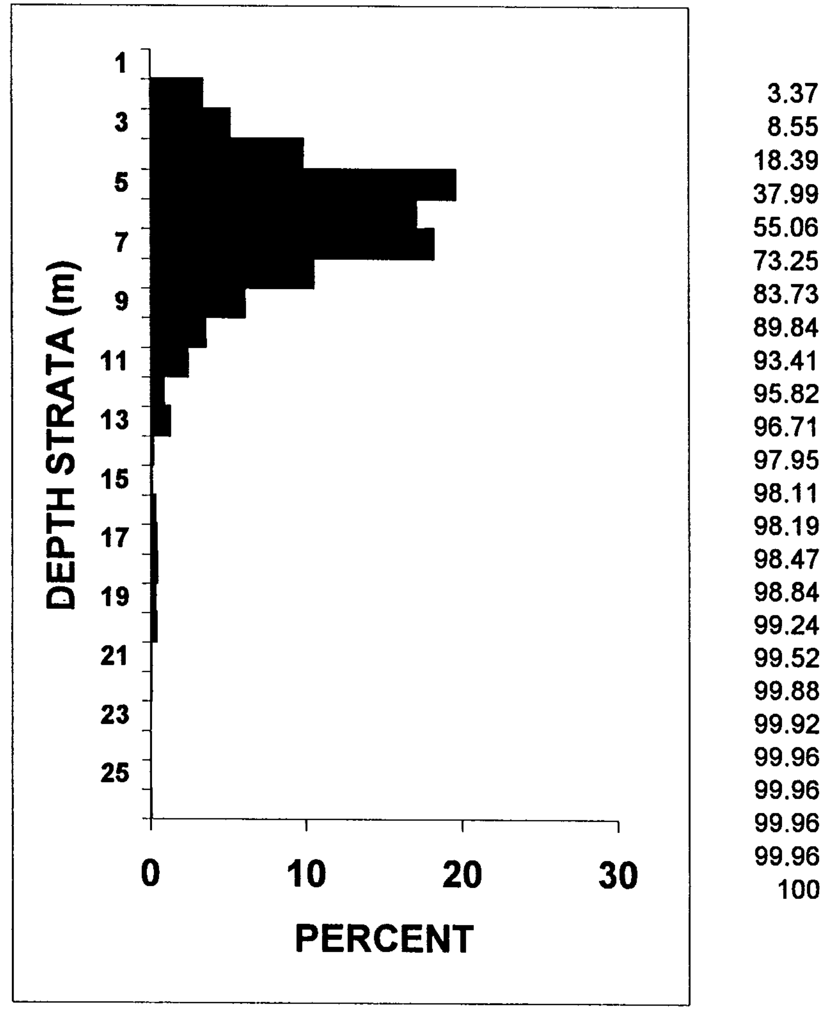
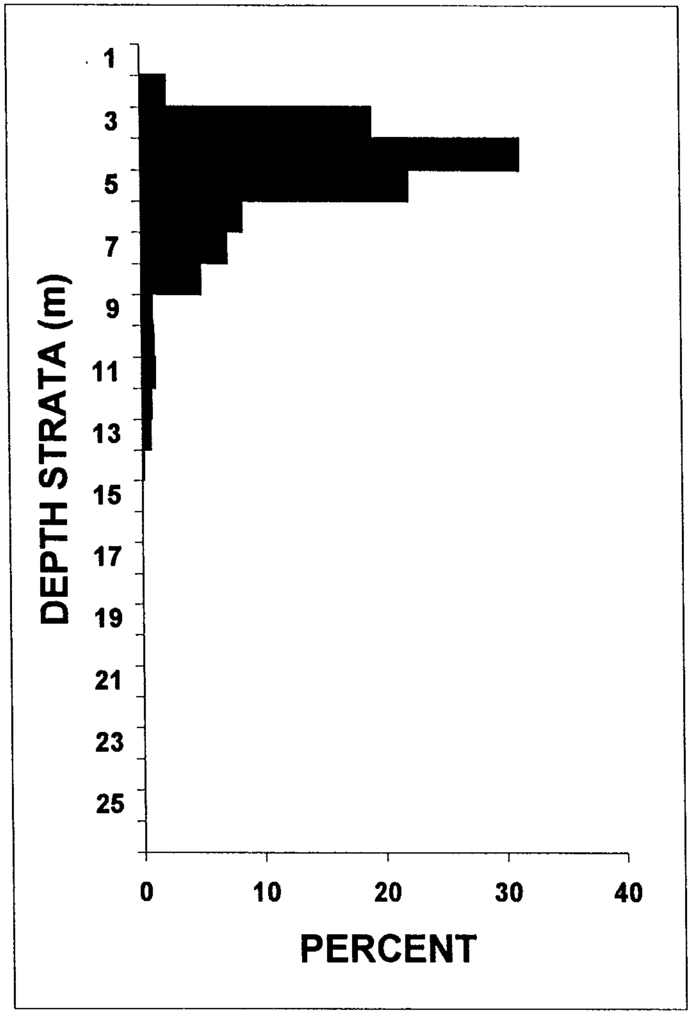
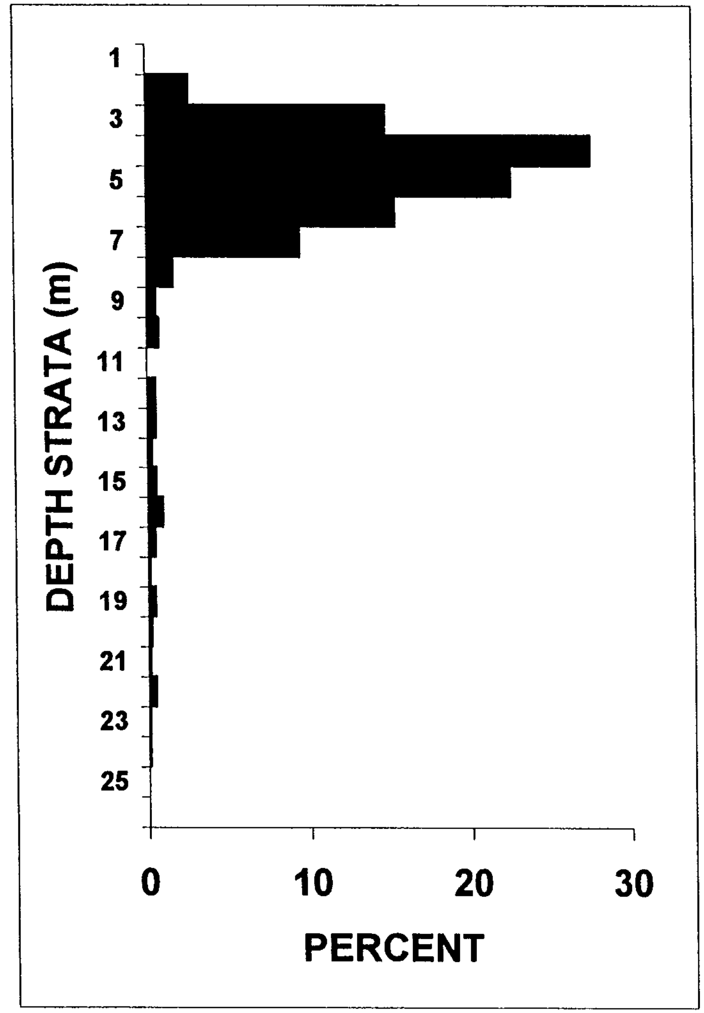


Figure 34. Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 2 (left graph) and within 20-30 m of the powerhouse (right graph) during the day in summer.



2.16
21.25
52.61
74.77
83.18
90.34
95.34
96.25
97.27
98.41
99.2
99.89
100
100
100
100
100
100
100
100
100
100
100
100
100



2.67
17.41
44.94
67.56
82.88
92.34
94
94.58
95.3
95.3
95.81
96.32
96.6
97.11
98.05
98.48
98.63
99.06
99.28
99.42
99.86
99.93
100
100
100

Figure 35. Average vertical distributions of smolt-sized fish 50-75 m upstream of Powerhouse 2 (left graph) and within 20-30 m of the powerhouse (right graph) at night in summer.

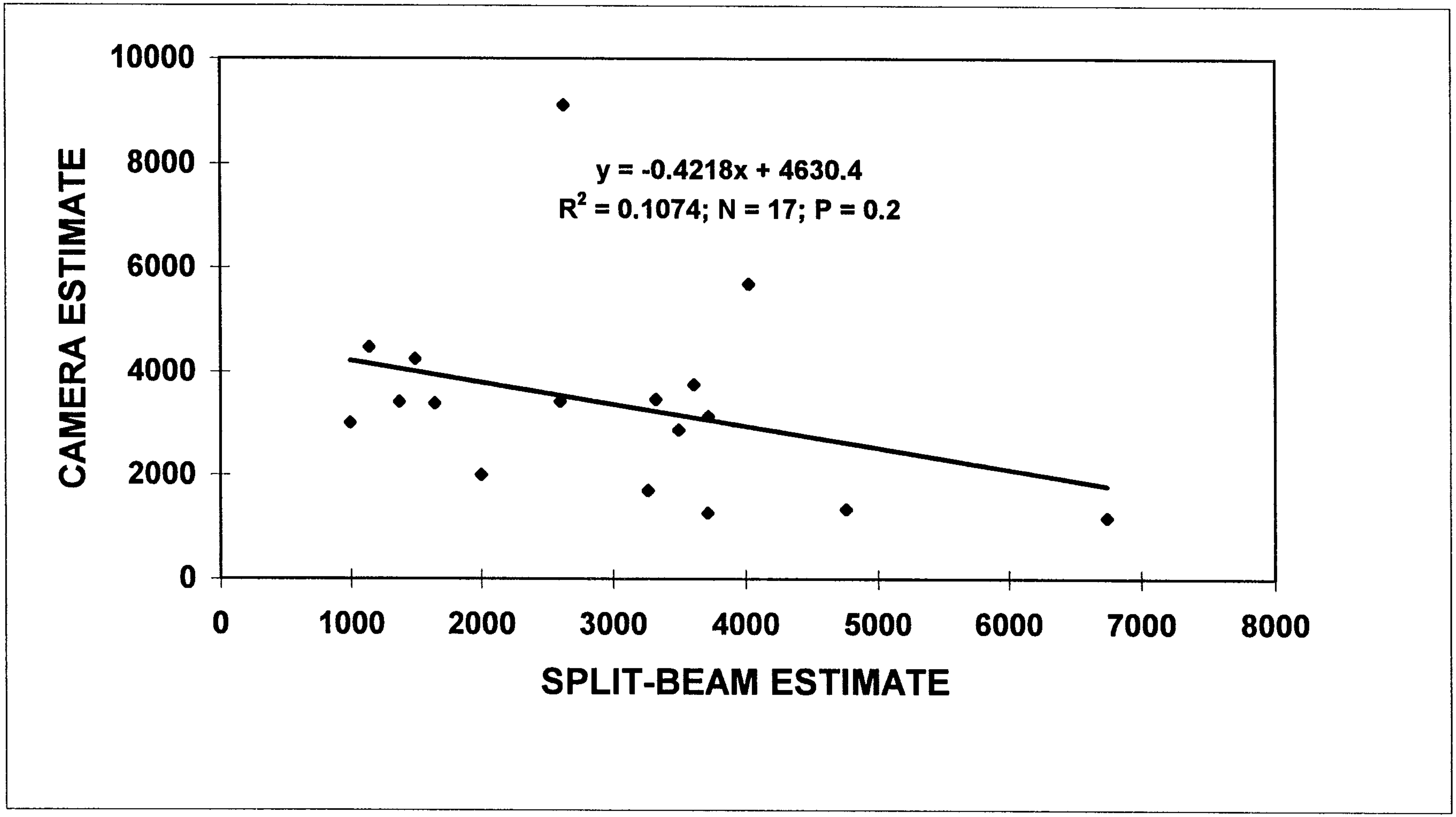


Figure 36. Lack of correlation of the split-beam estimates of the flux of fish into sluice 5B with estimates from underwater video cameras.

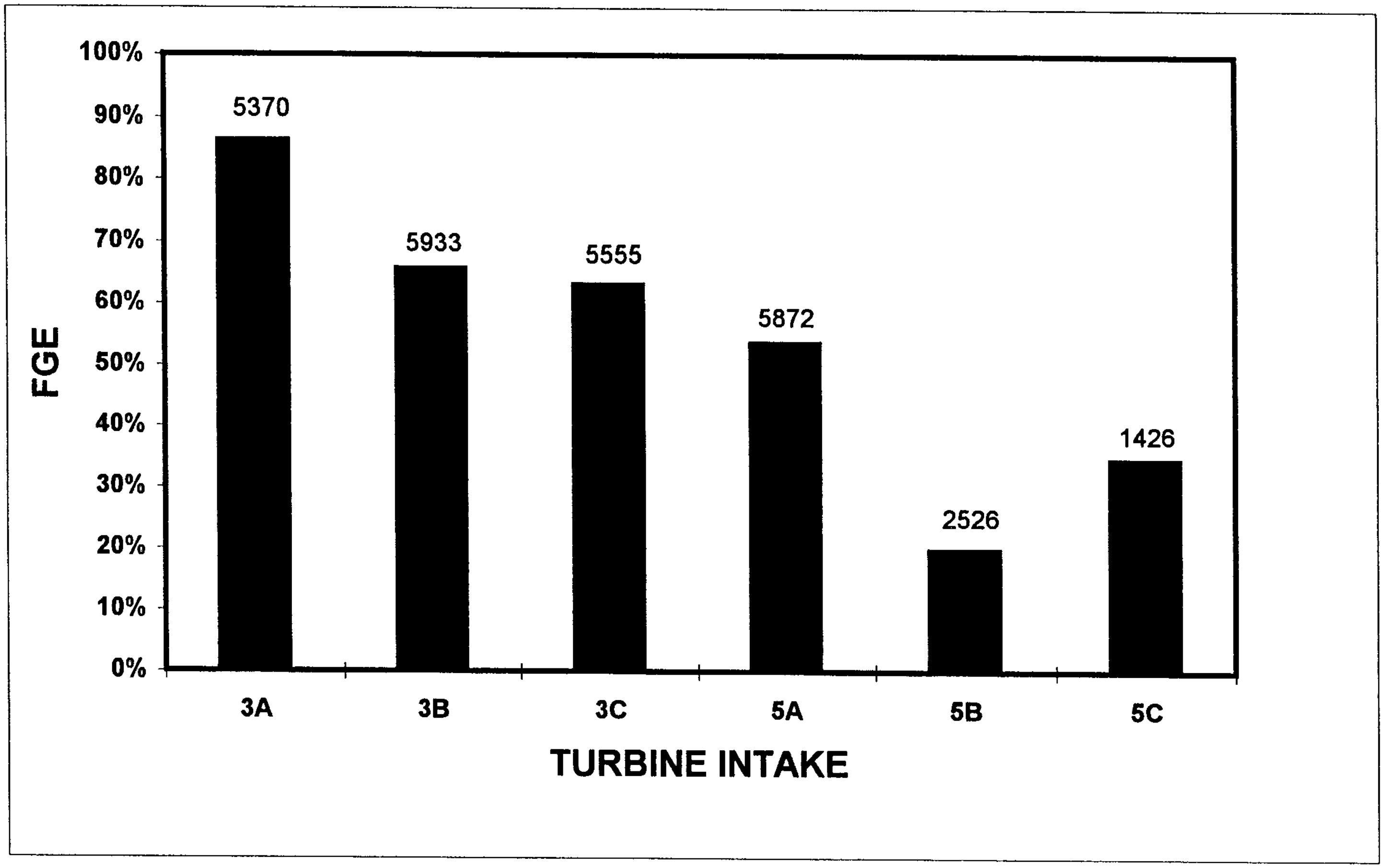


Figure 37. Fish guidance efficiency (FGE) among intakes of test turbines at Bonneville Powerhouse 1 in spring 1996. Numbers above bars indicate total counts of guided and unguided fish per intake.

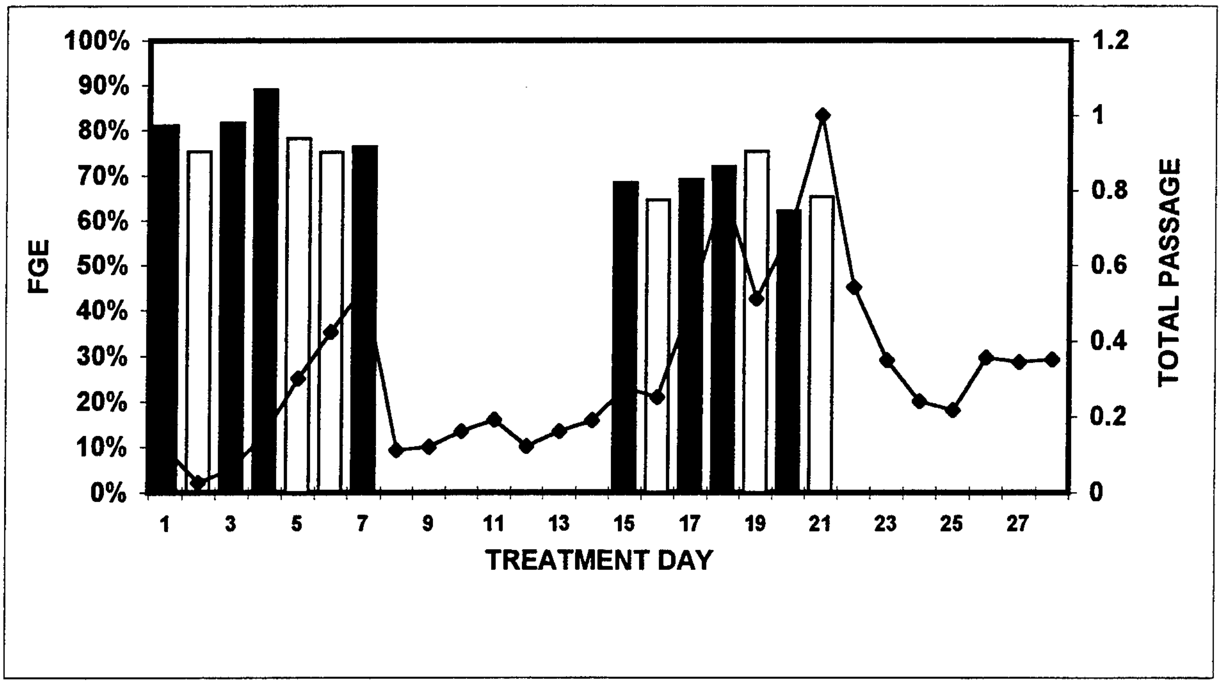


Figure 38. Mean fish guidance efficiency (FGE) during unblocked trash-rack treatments at Unit 3 in spring 1996. The sluice gate over the center intake was either opened (white bars) or closed (grey bars). The line shows the total smolt passage normalized to a maximum of 1.

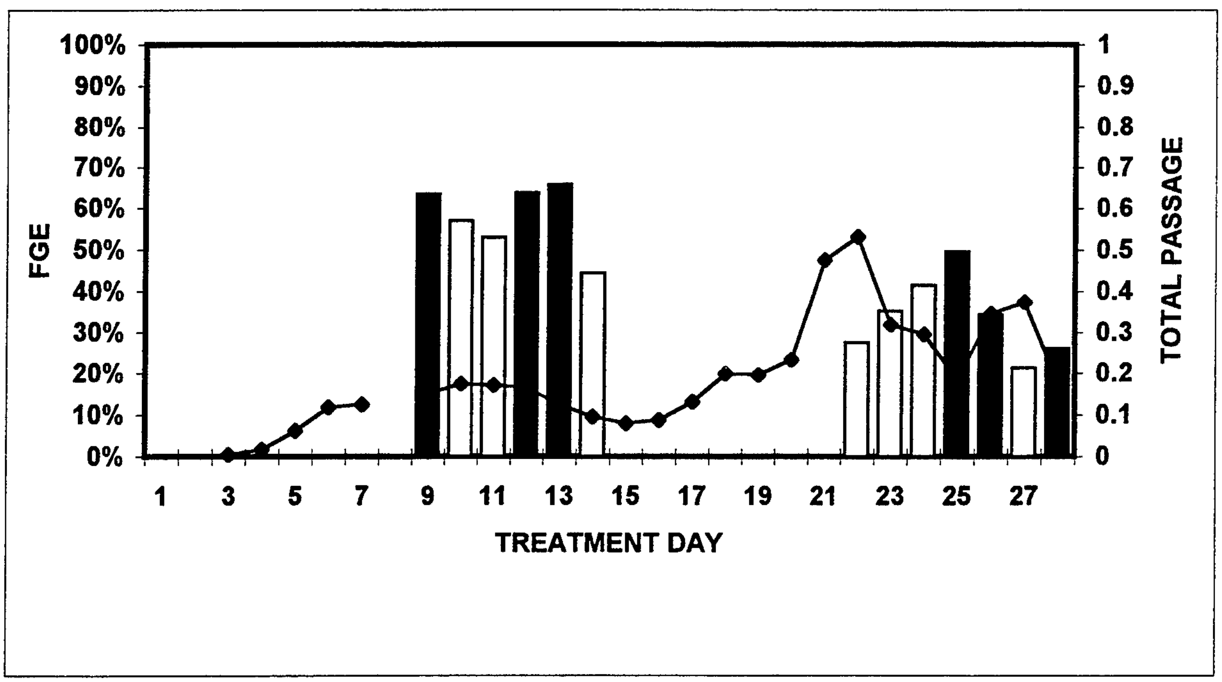


Figure 39. Mean fish guidance efficiency (FGE) during unblocked trash-rack treatments at Unit 5 in spring 1996. The sluice gate over the center intake was either opened (white bars) or closed (grey bars). The line shows the total smolt passage normalized to a maximum of 1.

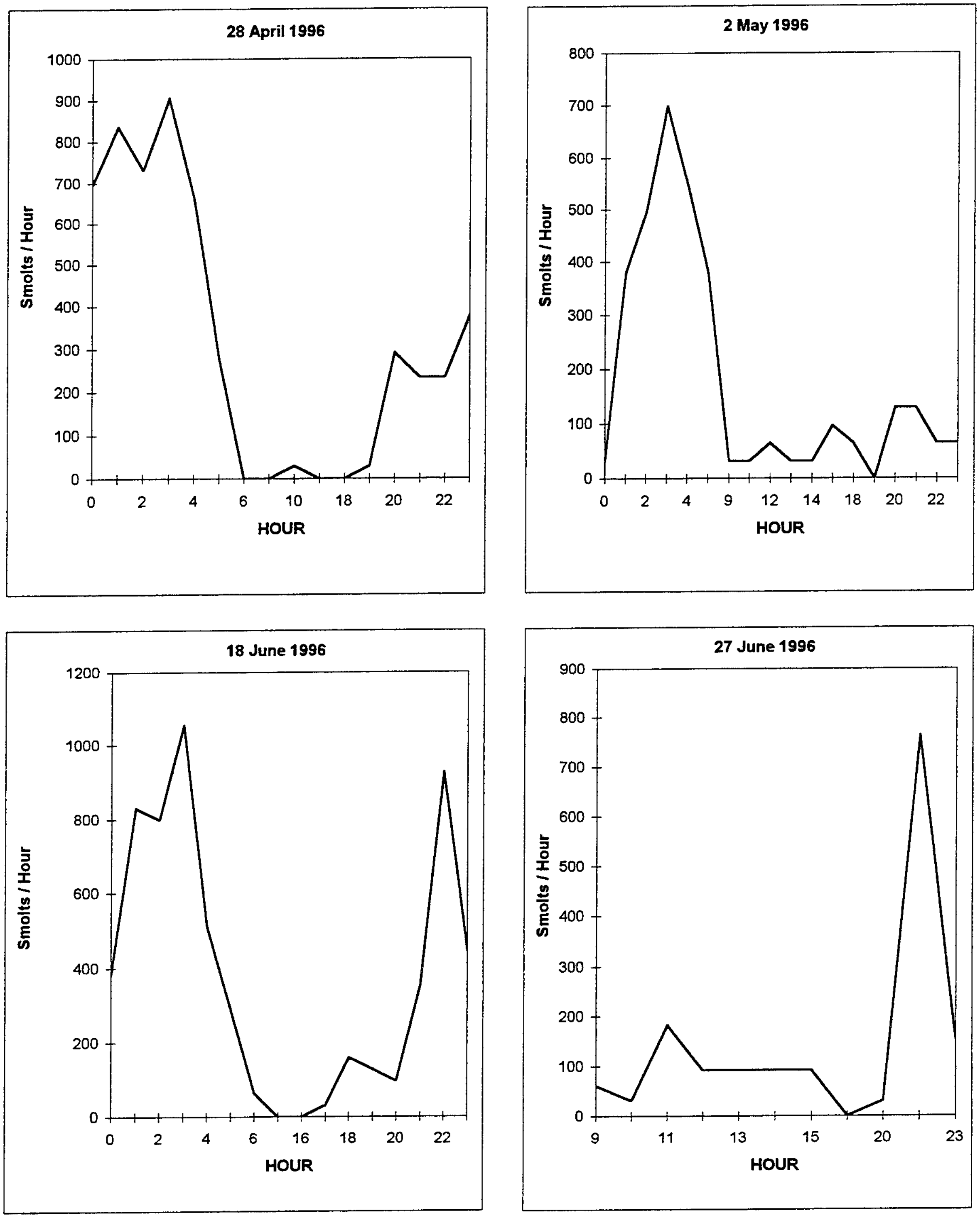
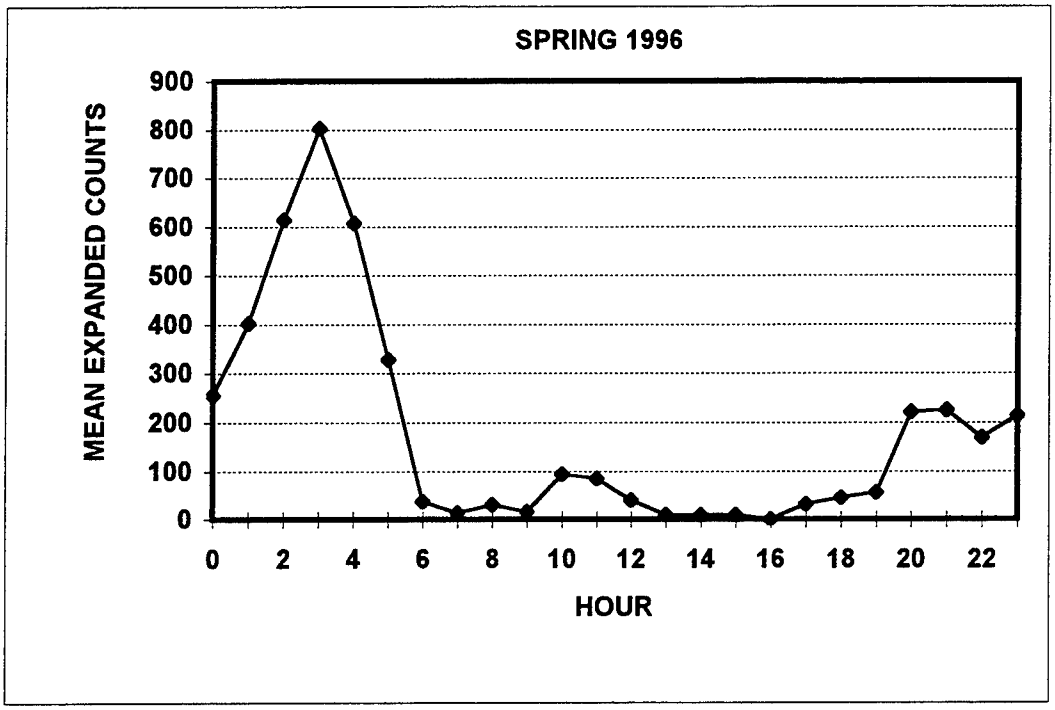
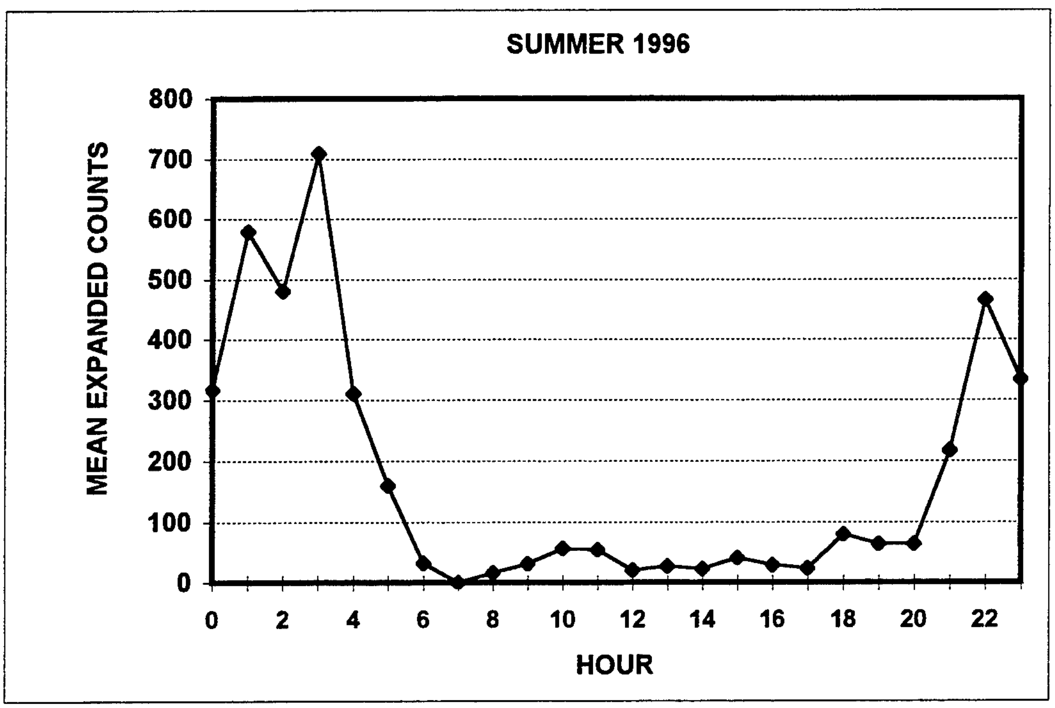


Figure 40. Diel smolt passage patterns at sluice opening 5B based upon expanded video counts for selected days in spring and summer.



HOUR	N
0	4
1	4
2	2
3	2
4	2
5	2
6	2
7	2
8	2
9	2
10	8
11	4
12	5
13	5
14	5
15	3
16	2
17	3
18	3
19	3
20	3
21	3
22	10
23	10



HOUR	N
0	2
1	2
2	2
3	2
4	2
5	2
6	2
7	2
8	4
9	3
10	4
11	7
12	6
13	6
14	7
15	9
16	7
17	3
18	3
19	2
20	2
21	2
22	13
23	13

Figure 41. Estimates of sluice passage by hour based on expanded video counts at Bonneville Powerhouse 1 Sluice 5B for spring and summer, 1996. Tables to the right of the plots list the number of hours (N) used to calculate the mean for each hour of the day.

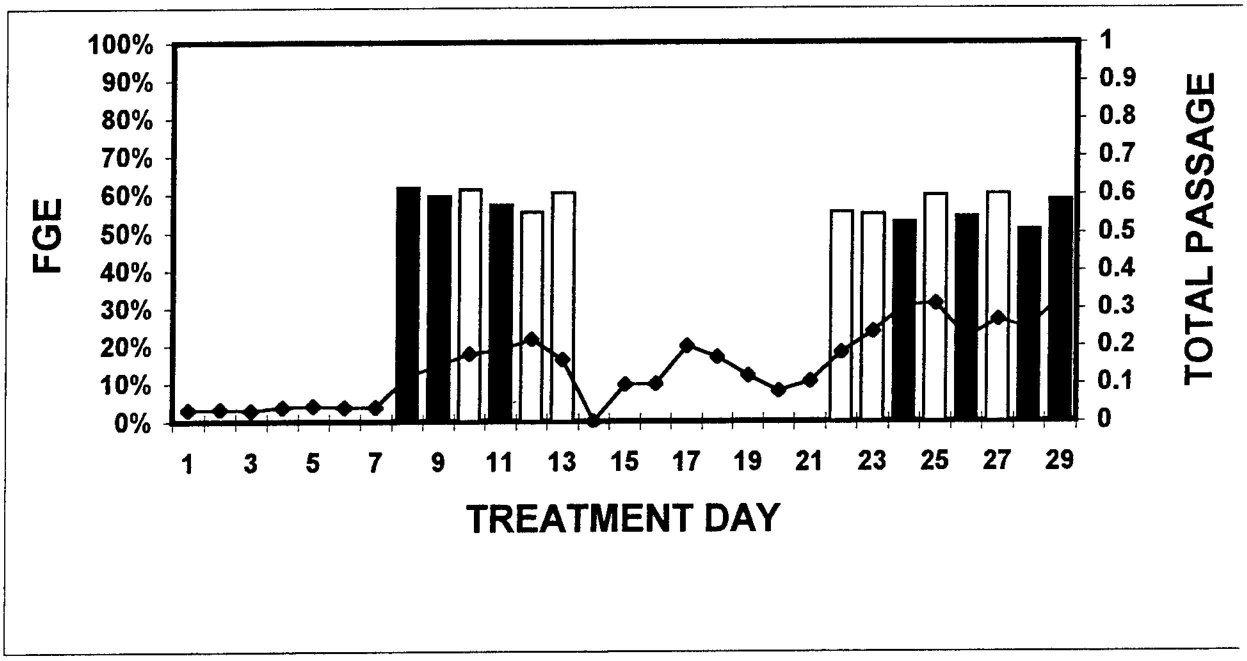


Figure 42. Mean fish guidance efficiency (FGE) during unblocked trash-rack treatments at Unit 3 in summer 1996. The sluice gate over the center intake was either opened (white bars) or closed (grey bars). The line shows the total smolt passage normalized to a maximum of 1.

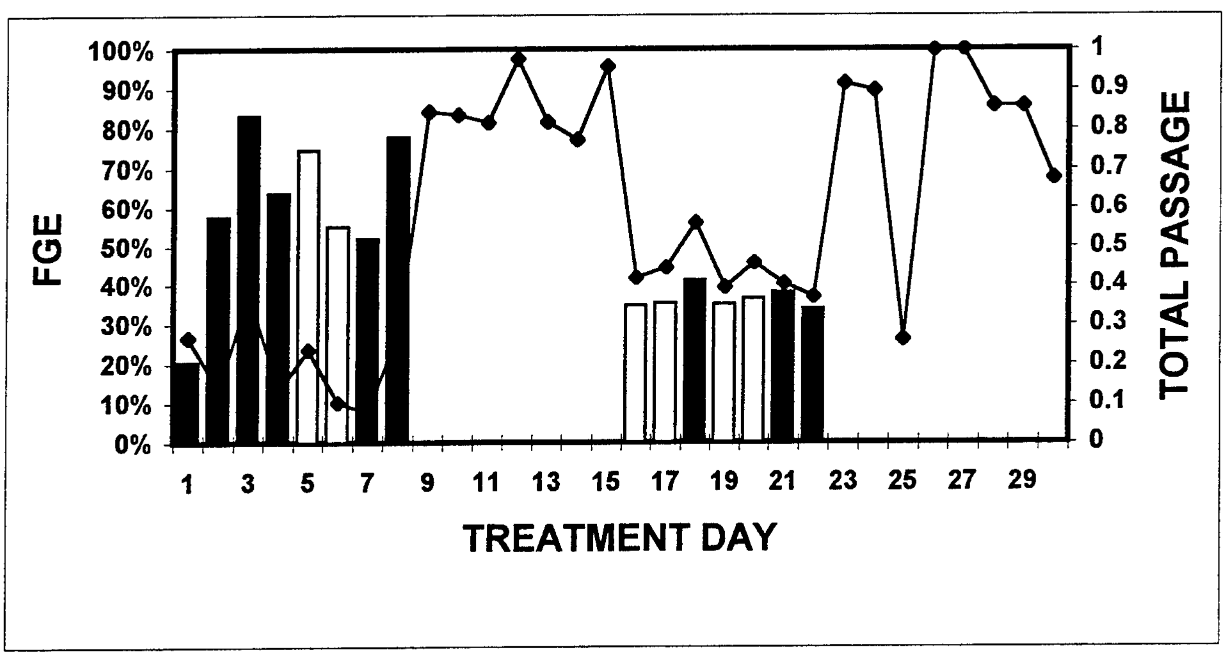


Figure 43. Mean fish guidance efficiency (FGE) during unblocked trash-rack treatments at Unit 5 in summer 1996. The sluice gate over the center intake was either opened (white bars) or closed (grey bars). The line shows the total smolt passage normalized to a maximum of 1.

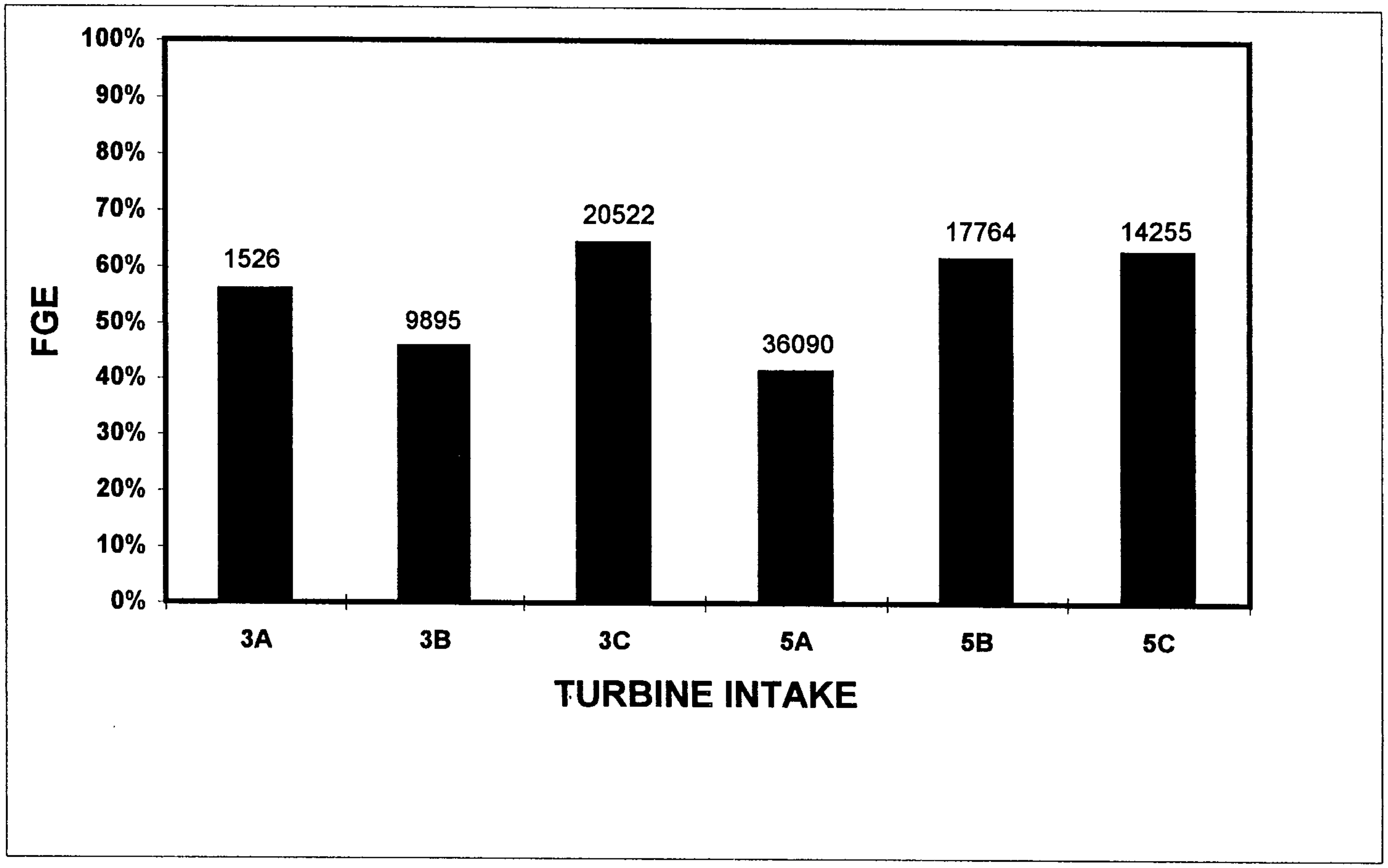


Figure 44. Fish guidance efficiency (FGE) among intakes of test turbines at Bonneville Powerhouse 1 in summer 1996. Numbers above bars indicate total counts of guided and unguided fish per intake.

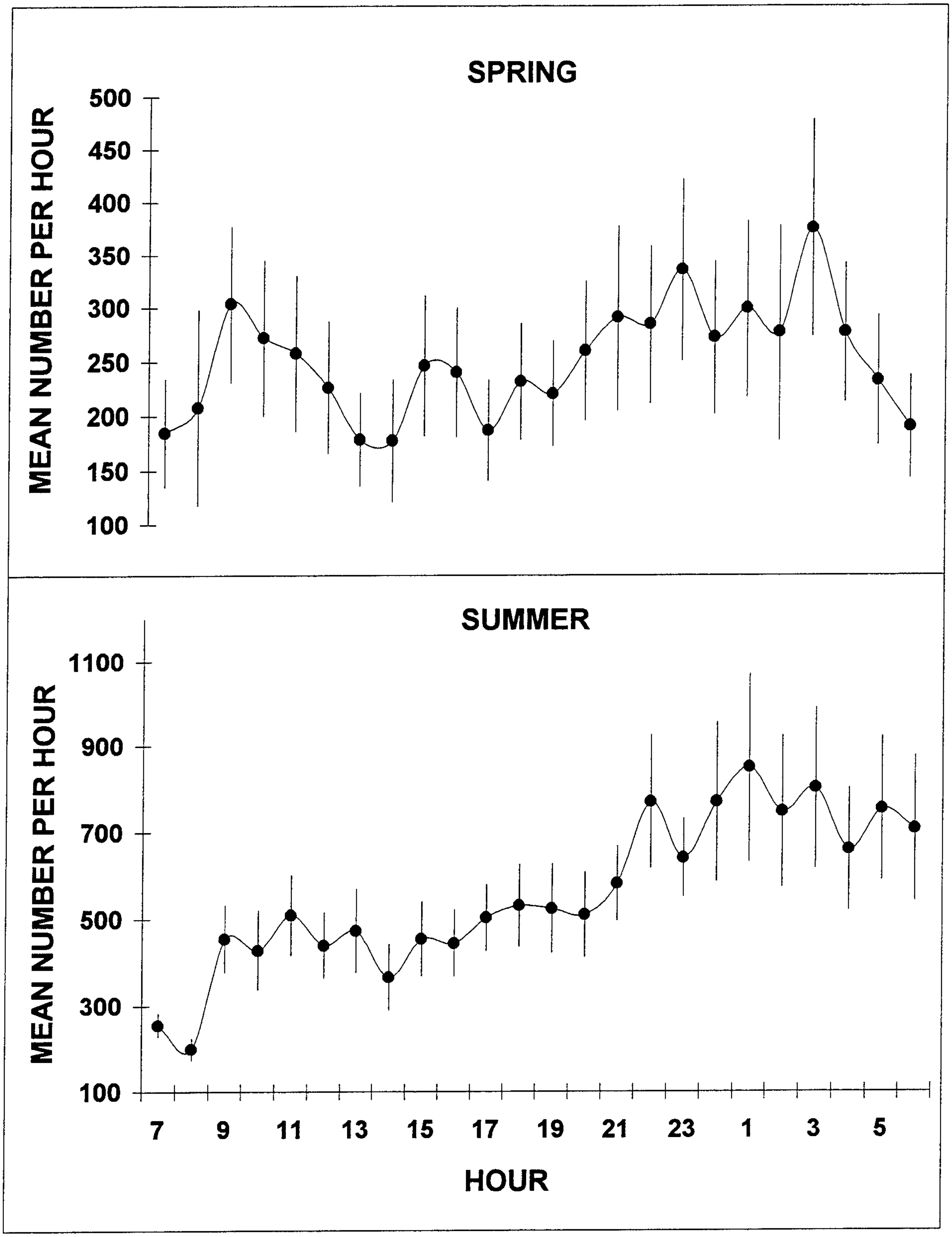


Figure 45. Mean diel patterns of smolt passage into turbines (guided and unguided fish) at Powerhouse 1 in spring and summer with error bars representing the standard error of the mea

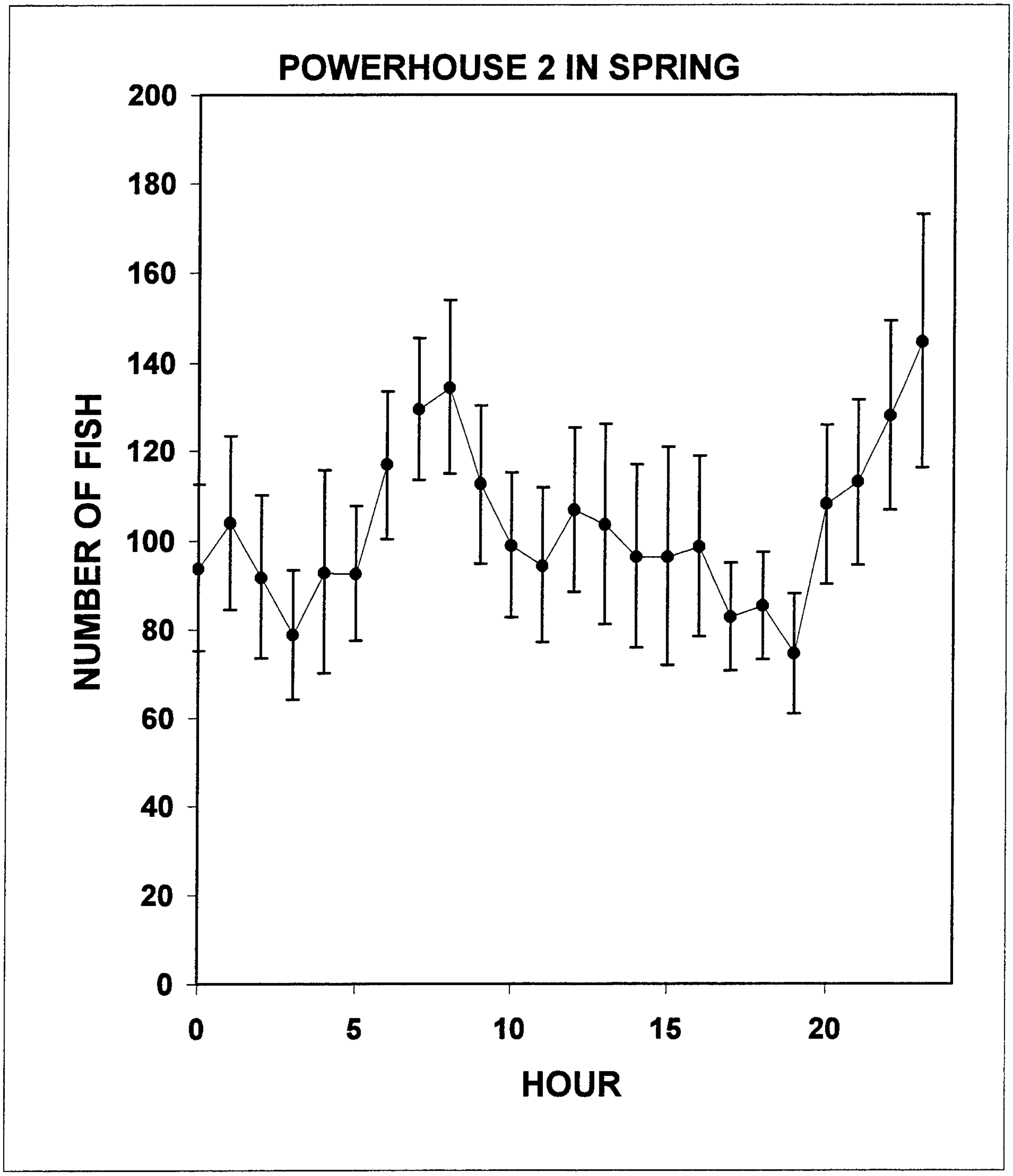


Figure 46. Average diel pattern of total smolt passage into intakes at Powerhouse 2 in spring.

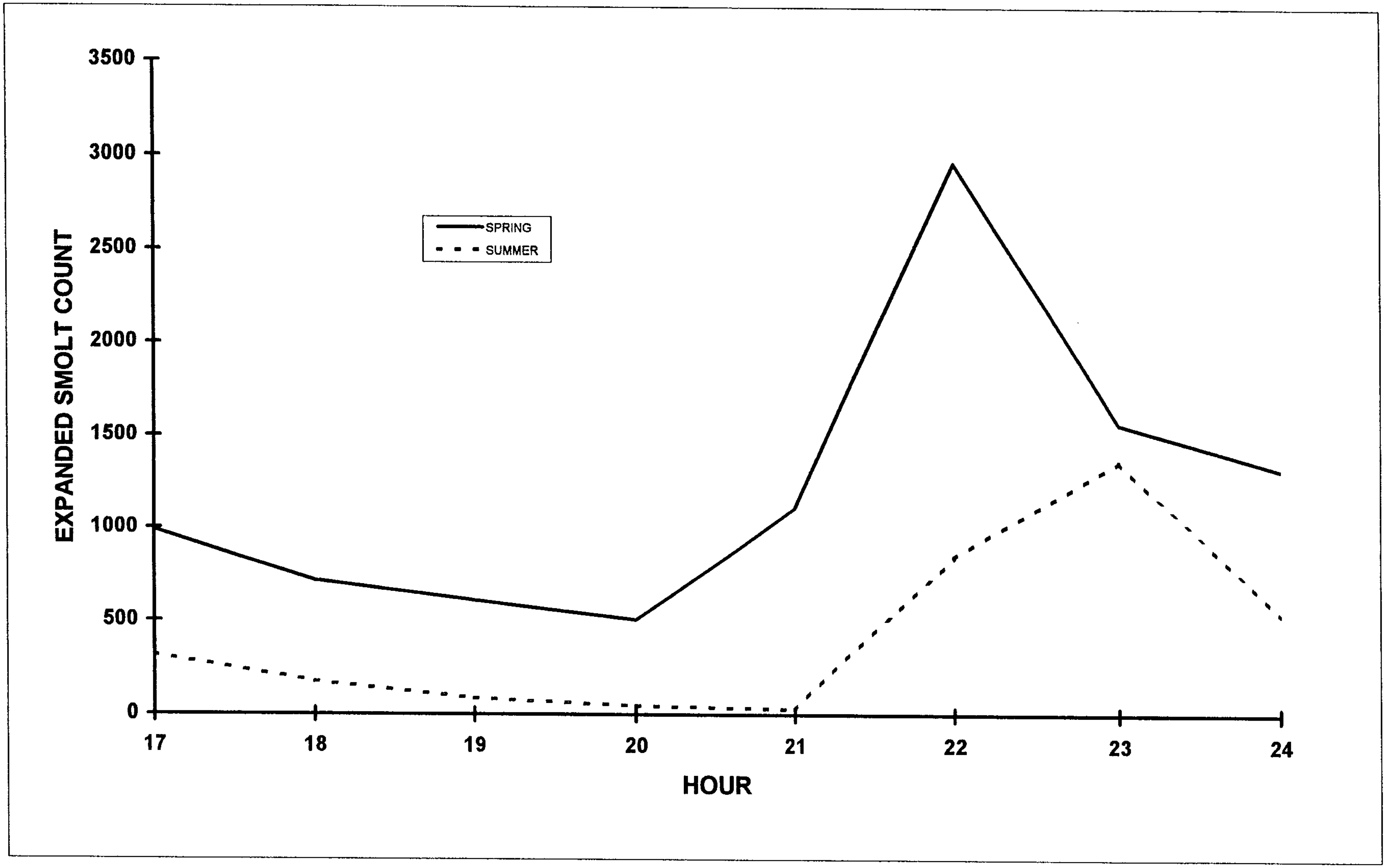
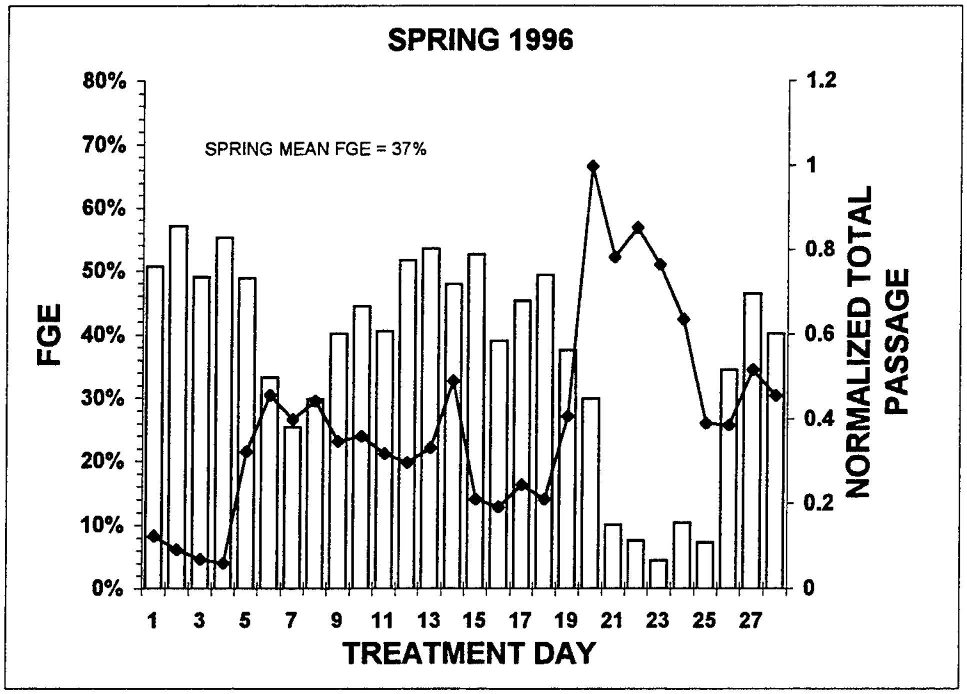


Figure 47. Diel plot of the National Marine Fisheries Service (NMFS) juvenile bypass data by hour in spring and summer, 1996. In 1996, the NMFS only sampled the hours shown on the plot. Smolt counts relect sub-samples expanded to full hours.



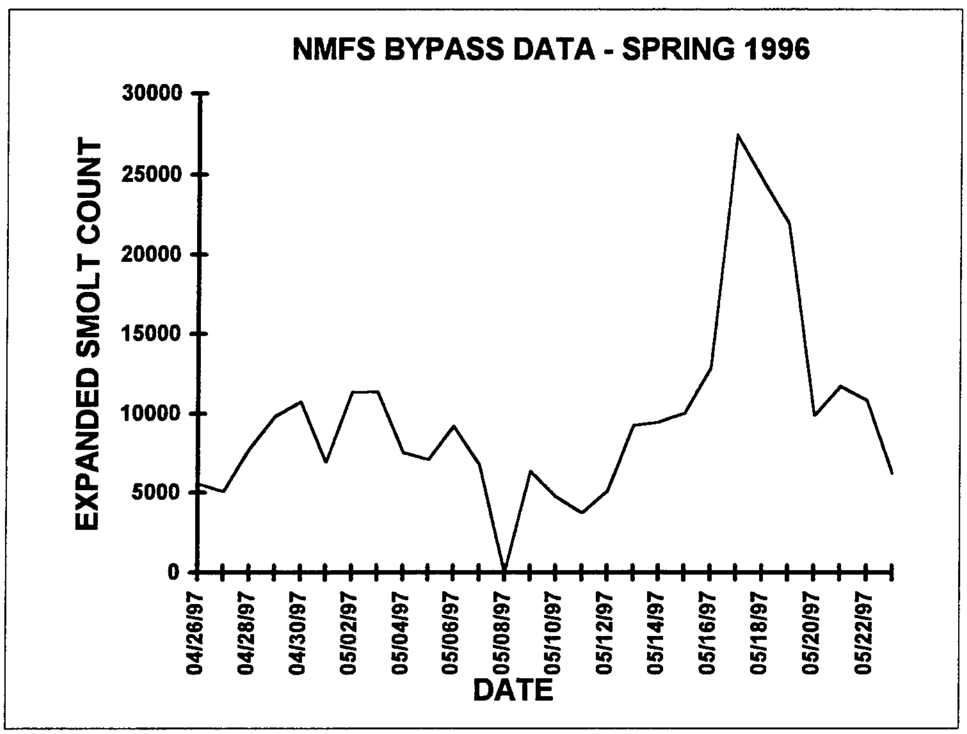


Figure 48. Plot of fish guidance efficiency (FGE) and normalized total passage by treatment day in spring at Powerhouse 2 (upper plot) and National Marine Fisheries Service juvenile bypass data by spring date in 1996 (lower plot). Bars represent mean FGE across the powerhouse for each treatment day. The horizontal line is the grand mean for spring. Total passage values were normalized to a maximum of 1. Mean FGE for the season is shown in the upper left corner. Bypass counts reflect sub-samples expanded to full hours. Dates along the abscissa coincide with spring treatment days.

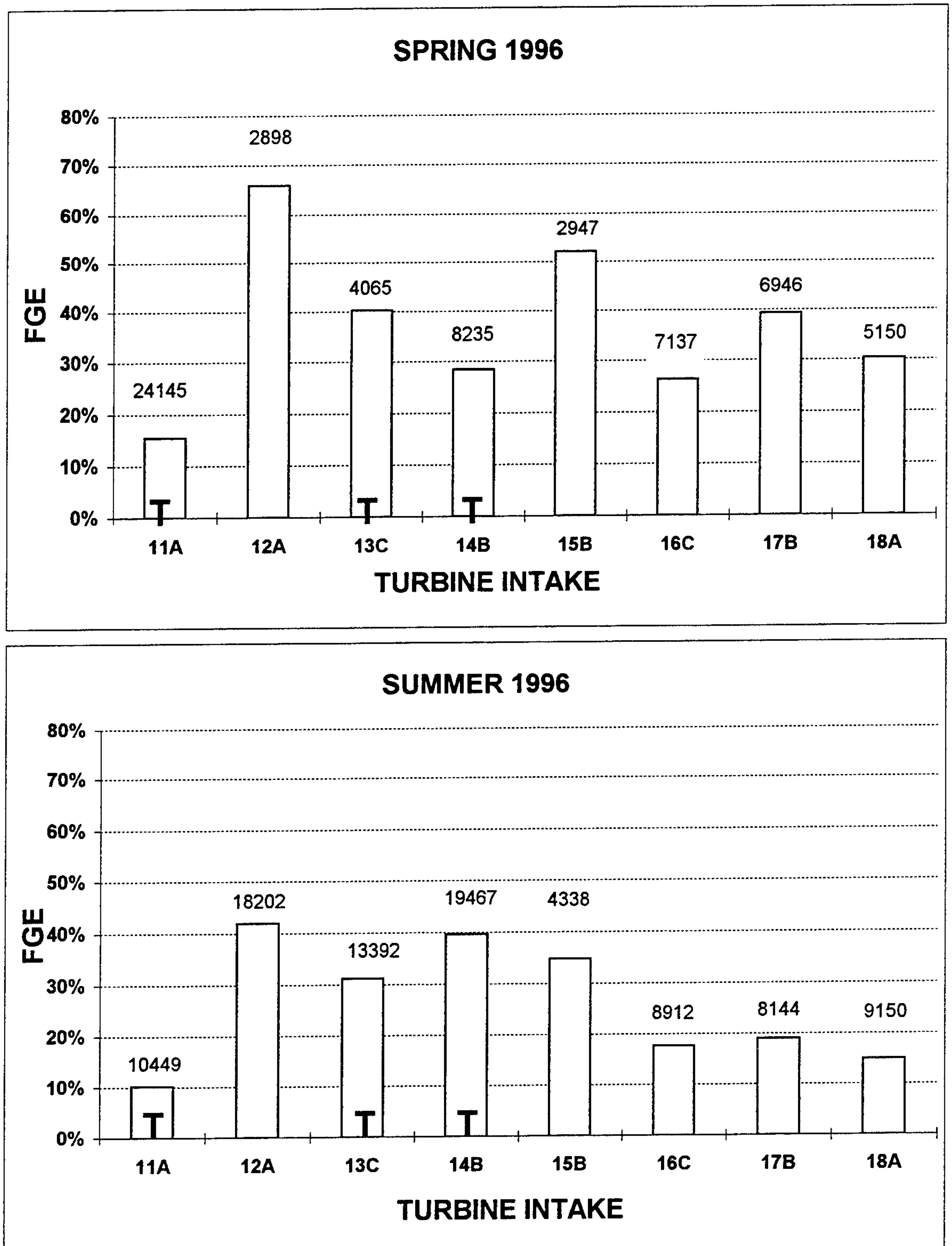
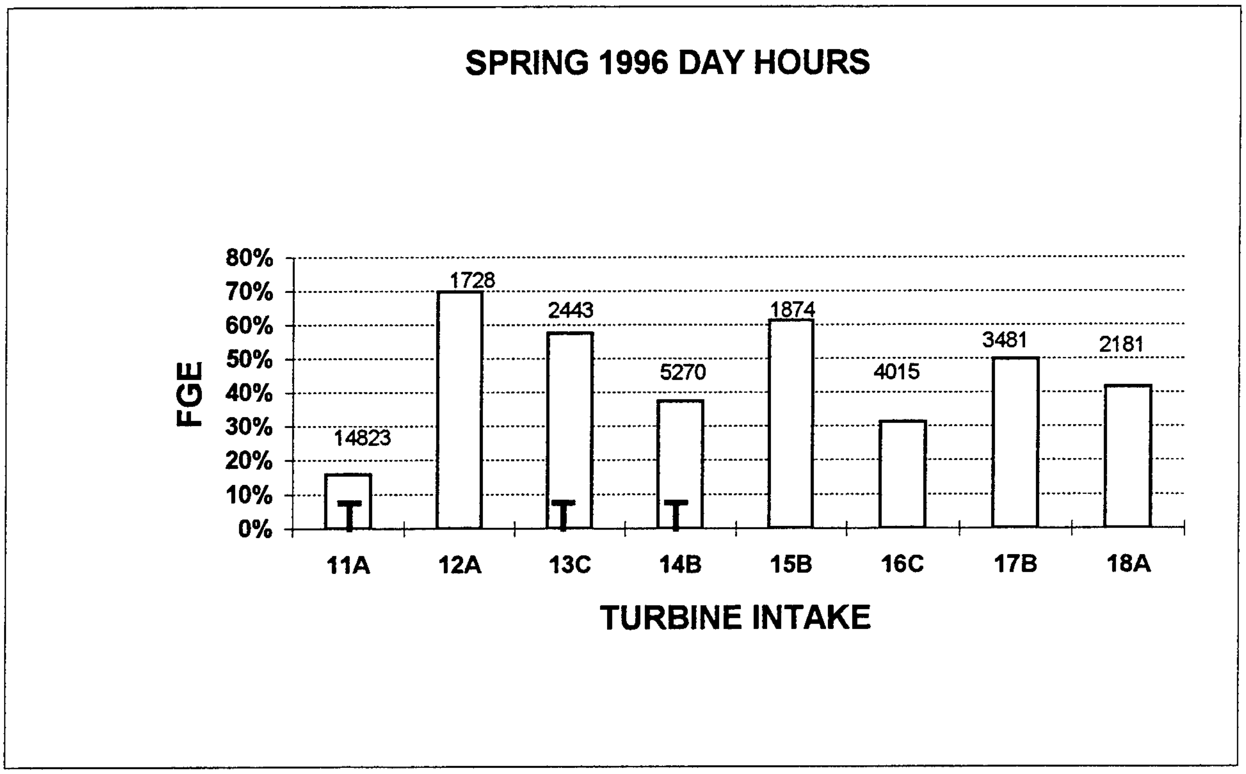


Figure 49. Plot of fish guidance efficiency (FGE) by turbine intake in spring and summer at Powerhouse 2. Bars represent mean FGE based on all hours for each intake through the seasons. Values above the bars indicate total smolt passage for each intake. A "T" at the base of some of the bars indicates that a turbine intake extension was present.



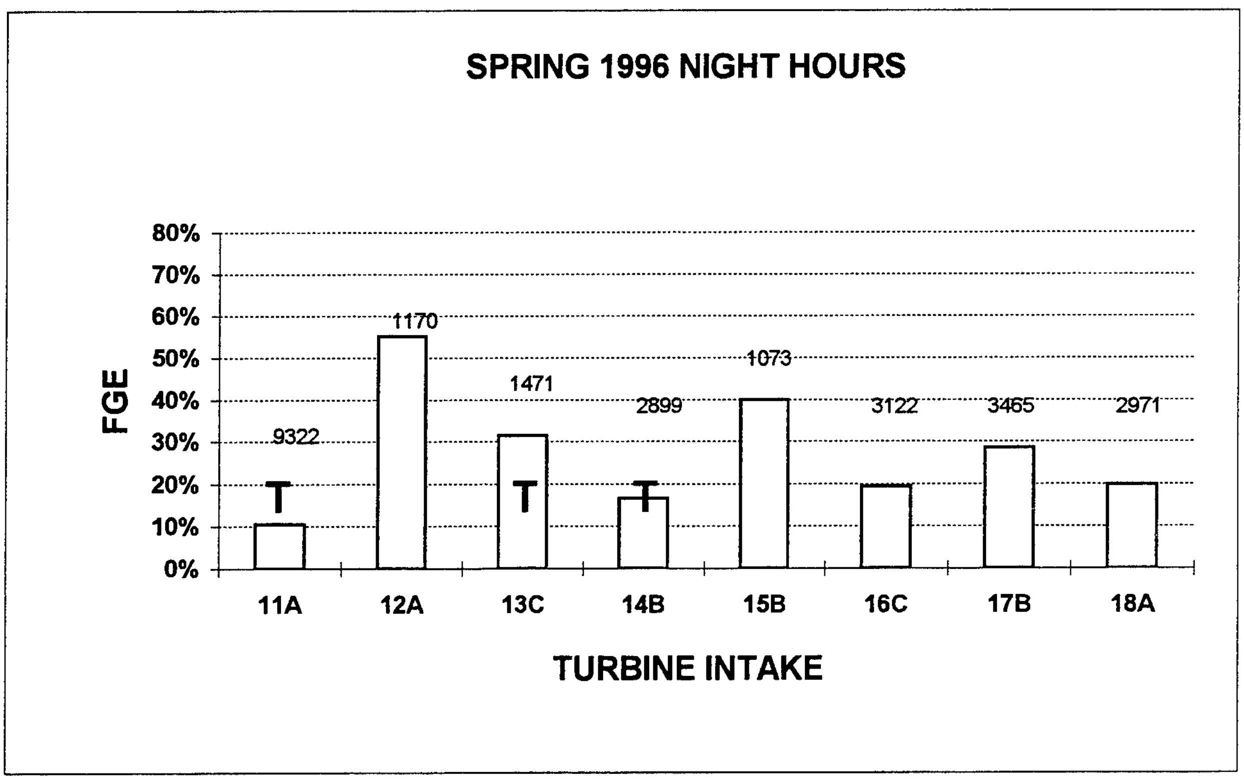


Figure 50. Plots of fish guidance efficiency (FGE) by turbine intake for day and night hours in spring at Powerhouse 2. Bars represent mean FGE based on day or night hours for each intake through the season. Values above the bars indicate total smolt passage for each intake during those hours. A "T" at the base of some of the bars indicates that a turbine intake extension was present.

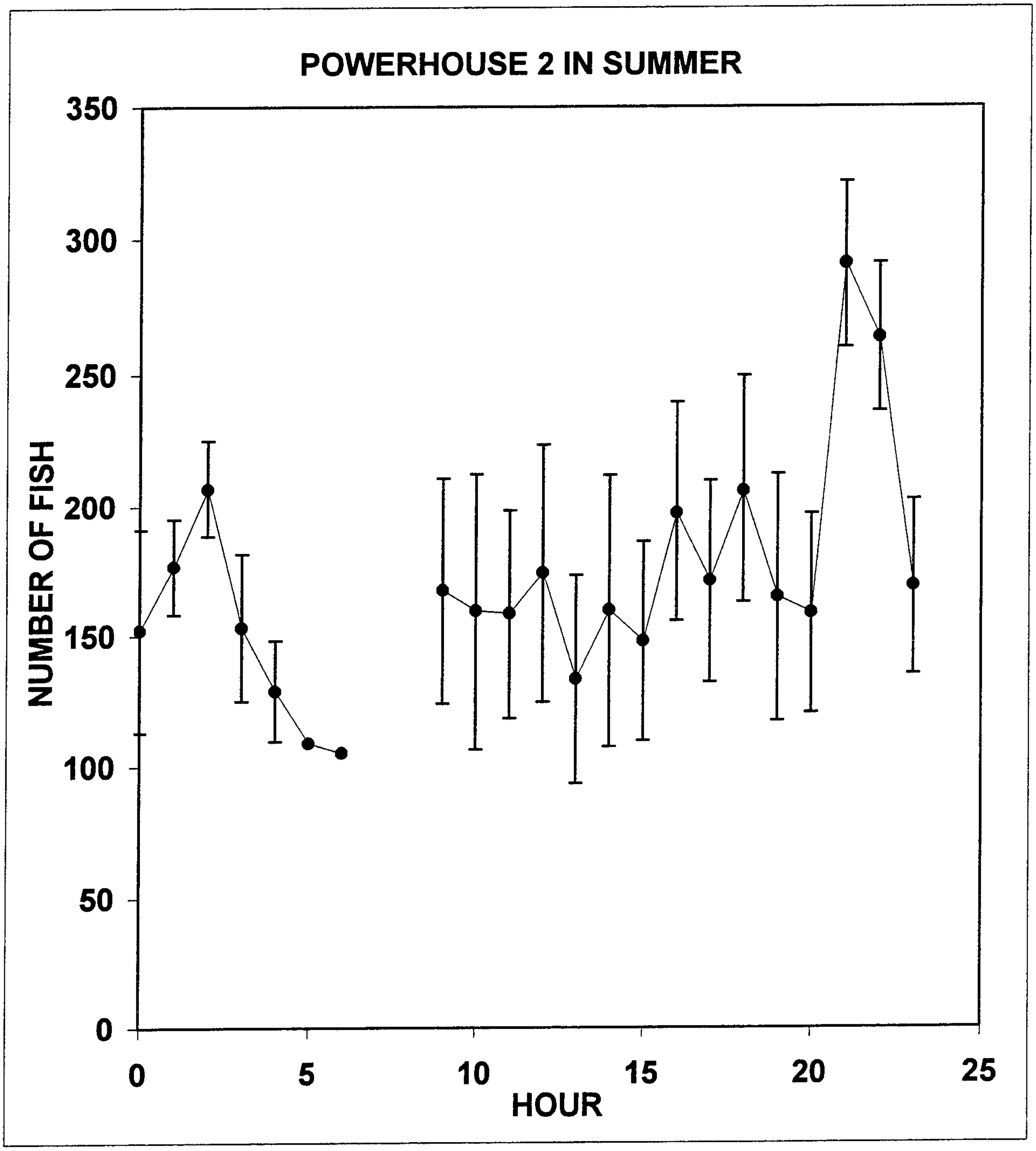


Figure 51. Average diel pattern of total smolt passage into intakes at Powerhouse 2 in summer.

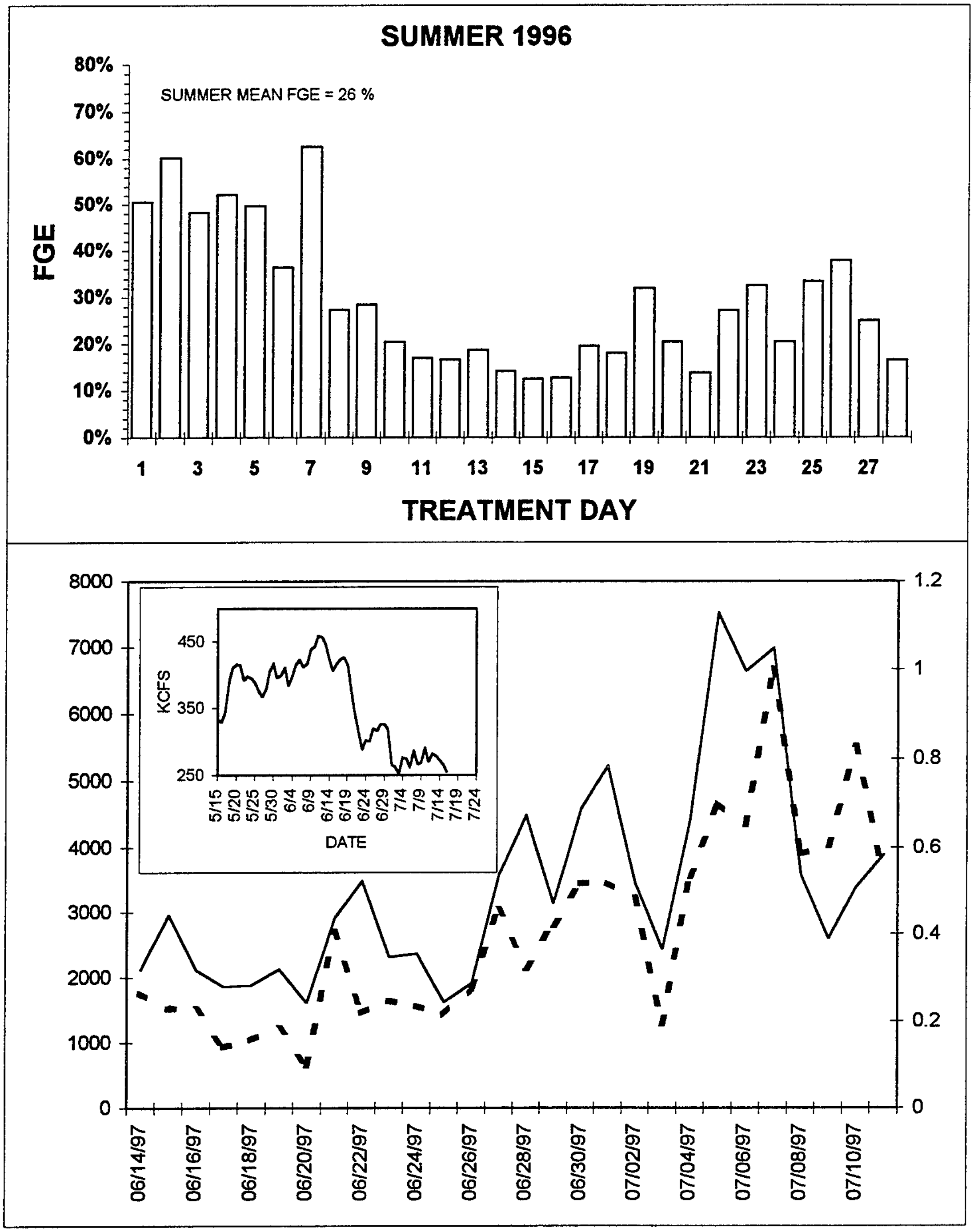


Figure 52. Plot of fish guidance efficiency (FGE) and normalized total passage by treatment day in summer at Powerhouse 2. Bars represent mean FGE across the powerhouse for each treatment day. Acoustic estimates of turbine passage were normalized to a maximum of 1 and excluded high estimates from units 11-14 for the first week of sampling after the highest forebay inflows for the year (see inset) loaded the eddy on the south end of the powerhouse with debris. Mean FGE for the season is shown in the upper left corner. Also shown is a plot of NMFS bypass data by summer date, 1996. Smolt counts reflect sub-samples expanded to full hours. Dates along the x axis of the bottom plot coincide with summer treatment days in the upper plot.

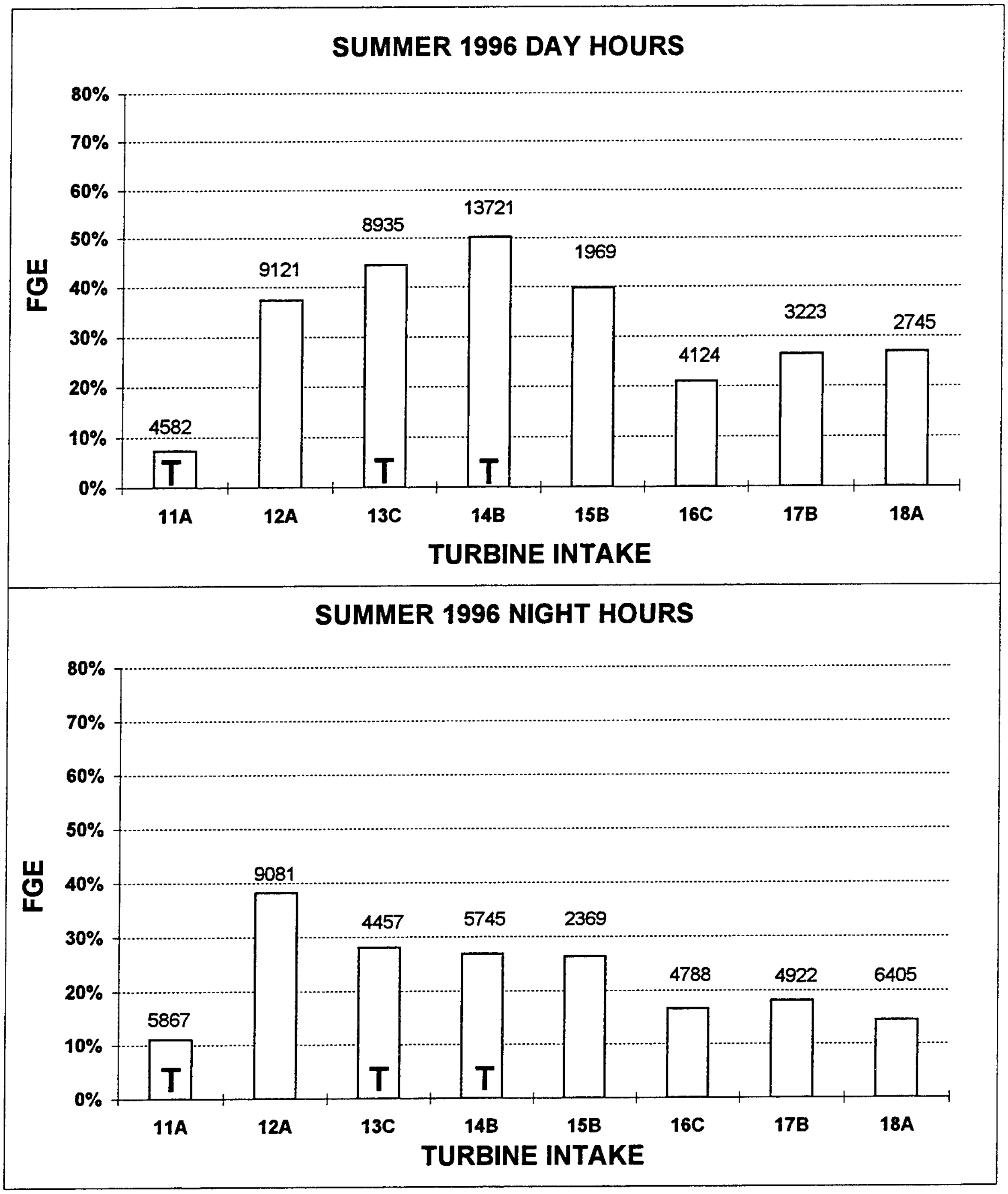


Figure 53. Plots of fish guidance efficiency (FGE) by turbine intake for day and night hours in summer at Powerhouse 2. Bars represent mean FGE based on day or night hours for each intake through the season. Values above the bars indicate total smolt passage for each intake during those hours. A "T" at the base of some of the bars indicates that a turbine intake extension was present.

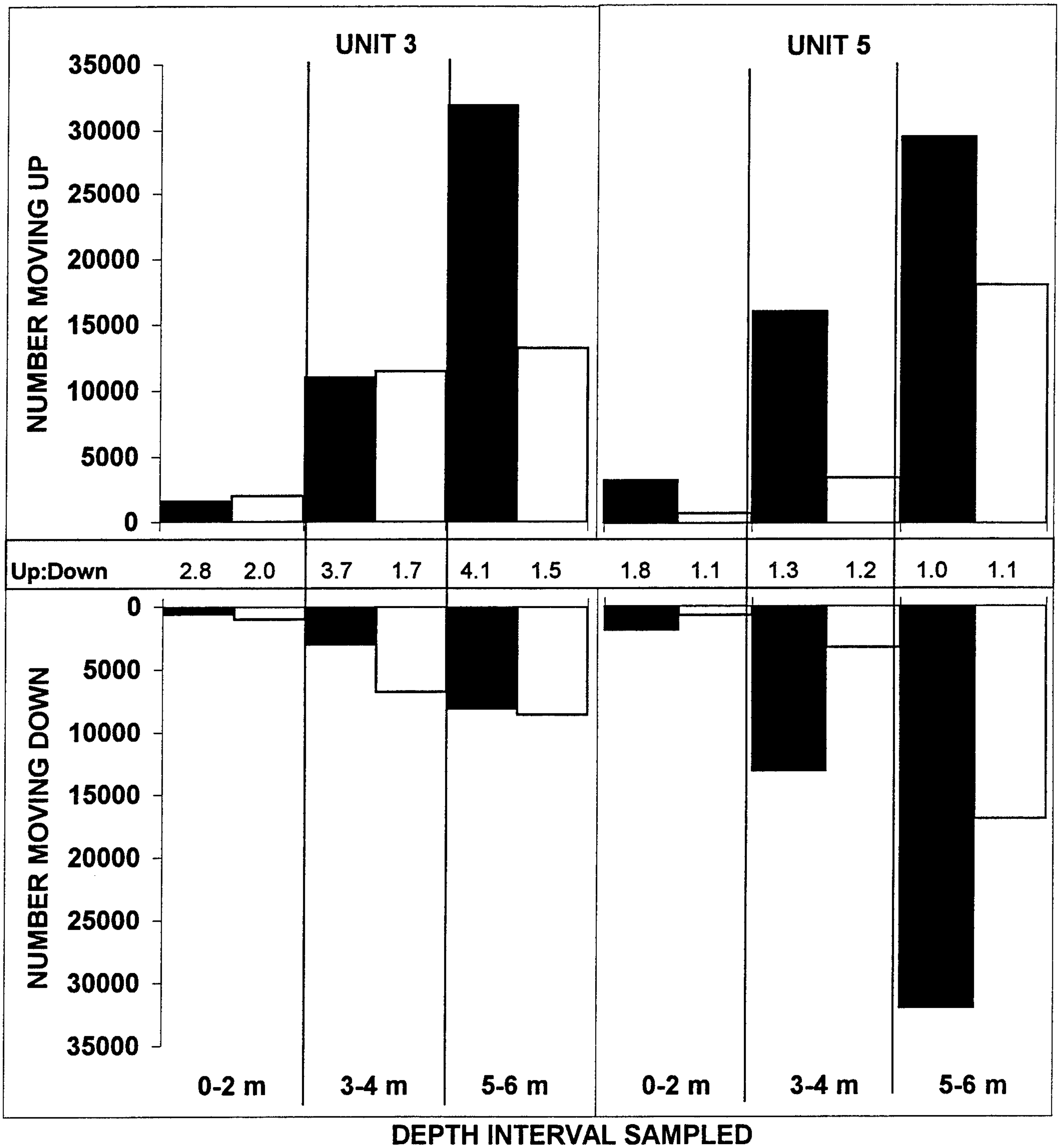


Figure 54. Plots showing the number of smolt-sized fish moving up or down in the water column 3-4 m upstream of trash racks of center intakes of Unit 3 and 5 when the sluice gate was open. Trash rack treatments are indicated by the color of bars (black = blocked; white = unblocked). Positive and negative vectors indicate upward and downward movement, respectively.

Appendix A
Statistical Tests on Powerhouse 1 Data from Spring 1996

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS AND UNITS FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED
UNIT	2	3 5

Number of observations in data set = 56
NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.71148245	6.61	0.0008
Error	49	1.75825564		
Corrected Total	52	2.46973809		

R-Square	C.V.	STP Mean
0.288080	74.03376	0.25586635

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.25034378	6.98	0.0111
UNIT	1	0.32242414	8.99	0.0043
BTRT*UNIT	1	0.13871453	3.87	0.0550

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.23947485	6.67	0.0128
UNIT	1	0.31339910	8.73	0.0048
BTRT*UNIT	1	0.13871453	3.87	0.0550

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS AND UNITS FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	4	BC BO UC UO
UNIT	2	3 5

Number of observations in data set = 56
NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	7	0.73092031	2.70	0.0200
Error	45	1.73881778		
Corrected Total	52	2.46973809		

R-Square	C.V.	STP Mean
0.295951	76.82589	0.25586635

Source	DF	Type I SS	F Value	Pr > F
TREAT	3	0.27046776	2.33	0.0867
UNIT	1	0.31185404	8.07	0.0067
TREAT*UNIT	3	0.14859851	1.28	0.2921

Source	DF	Type III SS	F Value	Pr > F
TREAT	3	0.23703759	2.04	0.1210
UNIT	1	0.29486578	7.63	0.0083
TREAT*UNIT	3	0.14859851	1.28	0.2921

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 3 & 5 Pooled)
FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	4	BC BO UC UO

Number of observations in data set = 56

NOTE: Due to missing values, only 53 observations can be used in this analysis.

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.27046776	2.01	0.1250
Error	49	2.19927033		
Corrected Total	52	2.46973809		

R-Square	C.V.	STP Mean
0.109513	82.79957	0.25586635

Source	DF	Type I SS	F Value	Pr > F
TREAT	3	0.27046776	2.01	0.1250

Source	DF	Type III SS	F Value	Pr > F
TREAT	3	0.27046776	2.01	0.1250

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 49 MSE= 0.044883
WARNING: Cell sizes are not equal.

Number of Means	2	3	4
Critical F	5.3223725	3.1865824	2.7939489

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.34942	14	UC
A			
A	0.29519	13	UO
A			
A	0.18948	12	BC
A			
A	0.18270	14	BO

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS AND UNITS FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED
UNIT	2	3 5

Number of observations in data set = 56
NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.32419732	2.47	0.0730
Error	49	2.14554077		
Corrected Total	52	2.46973809		

R-Square	C.V.	STP Mean
0.131268	81.78189	0.25586635

Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.01988339	0.45	0.5036
UNIT	1	0.29892890	6.83	0.0119
GTRT*UNIT	1	0.00538502	0.12	0.7273

Source	DF	Type III SS	F Value	Pr > F
GTRT	1	0.00854475	0.20	0.6606
UNIT	1	0.29624371	6.77	0.0123
GTRT*UNIT	1	0.00538502	0.12	0.7273

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS AND BLOCK TREATMENTS FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED
GTRT	2	OPEN CLOSED

Number of observations in data set = 56
NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.27046776	2.01	0.1250
Error	49	2.19927033		
Corrected Total	52	2.46973809		

R-Square	C.V.	STP Mean
0.109513	82.79957	0.25586635

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.25034378	5.58	0.0222
GTRT	1	0.01269722	0.28	0.5972
BTRT*GTRT	1	0.00742676	0.17	0.6859

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.24484917	5.46	0.0236
GTRT	1	0.01228423	0.27	0.6032
BTRT*GTRT	1	0.00742676	0.17	0.6859

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 3 & 5 Pooled)
FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in data set = 56
NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.25034378	5.75	0.0202
Error	51	2.21939431		
Corrected Total	52	2.46973809		

R-Square	C.V.	STP Mean
0.101365	81.53029	0.25586635

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.25034378	5.75	0.0202

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.25034378	5.75	0.0202

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 51 MSE= 0.043518
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 26.49057

Number of Means 2
Critical F 4.0303926

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.32331	27	UNBLKED
B	0.18583	26	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 3 & 5 Pooled)
FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 56

NOTE: Due to missing values, only 53 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.01988339	0.41	0.5229
Error	51	2.44985470		
Corrected Total	52	2.46973809		

R-Square	C.V.	STP Mean
0.008051	85.65878	0.25586635

Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.01988339	0.41	0.5229
Source	DF	Type III SS	F Value	Pr > F
GTRT	1	0.01988339	0.41	0.5229

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 51 MSE= 0.048036
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 26.49057

Number of Means	2
Critical F	4.0303926

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	0.27560	26	CLOSED
A			
A	0.23686	27	OPEN

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 3)
FOR SUMMED DATA
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	4	BC BO UC UO

Number of observations in data set = 28

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.00172135	2.03	0.1367
Error	24	0.00678936		
Corrected Total	27	0.00851071		

R-Square	C.V.	STP Mean
0.202257	78.17918	0.02151383

Source	DF	Type I SS	F Value	Pr > F
TREAT	3	0.00172135	2.03	0.1367

Source	DF	Type III SS	F Value	Pr > F
TREAT	3	0.00172135	2.03	0.1367

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 24 MSE= 0.000283
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 6.927835

Number of Means	2	3	4
Critical F	5.6887853	3.4028261	3.0087866

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.029777	8	UC
A			
A	0.028636	6	UO
A			
A	0.015065	7	BO
A			
A	0.012414	7	BC

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS (Unit 3)
FOR SUMMED DATA
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00169229	6.45	0.0174
Error	26	0.00681842		
Corrected Total	27	0.00851071		

R-Square	C.V.	STP Mean
0.198843	75.27268	0.02151383

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.00169229	6.45	0.0174

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.00169229	6.45	0.0174

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.000262

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.029288	14	UNBLKED
B	0.013740	14	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS (Unit 3)
FOR SUMMED DATA
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 28

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00000083	0.00	0.9602
Error	26	0.00850988		
Corrected Total	27	0.00851071		

R-Square	C.V.	STP Mean
0.000098	84.09251	0.02151383

Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.00000083	0.00	0.9602

Source	DF	Type III SS	F Value	Pr > F
GTRT	1	0.00000083	0.00	0.9602

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.000327
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.92857

Number of Means 2
Critical F 4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	0.021674	15	CLOSED
A			
A	0.021329	13	OPEN

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 5)
FOR SUMMED DATA
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	4	BC BO UC UO

Number of observations in data set = 28

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.00008221	0.85	0.4839
Error	21	0.00067973		
Corrected Total	24	0.00076194		

R-Square	C.V.	STP Mean
0.107889	49.66295	0.01145585

Source	DF	Type I SS	F Value	Pr > F
TREAT	3	0.00008221	0.85	0.4839

Source	DF	Type III SS	F Value	Pr > F
TREAT	3	0.00008221	0.85	0.4839

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 21 MSE= 0.000032
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 6.131387

Number of Means	2	3	4
Critical F	5.7978344	3.4668001	3.072467

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.013734	6	UC
A			
A	0.012425	5	BC
A			
A	0.011384	7	UO
A			
A	0.008883	7	BO

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS (Unit 5)
FOR SUMMED DATA
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00002777	0.87	0.3607
Error	23	0.00073417		
Corrected Total	24	0.00076194		

R-Square	C.V.	STP Mean
0.036440	49.31831	0.01145585

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.00002777	0.87	0.3607

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.00002777	0.87	0.3607

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 23 MSE= 0.000032
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 12.48

Number of Means 2
Critical F 4.2793443

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.012468	13	UNBLKED
A			
A	0.010359	12	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS (Unit 5)
FOR SUMMED DATA
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 28
NOTE: Due to missing values, only 25 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00005565	1.81	0.1914
Error	23	0.00070629		
Corrected Total	24	0.00076194		

R-Square	C.V.	STP Mean
0.073031	48.37282	0.01145585

Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.00005565	1.81	0.1914

Source	DF	Type III SS	F Value	Pr > F
GTRT	1	0.00005565	1.81	0.1914

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 23 MSE= 0.000031
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 12.32

Number of Means	2
Critical F	4.2793443

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	0.013139	11	CLOSED
A			
A	0.010133	14	OPEN

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS AND INTAKES
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	6	03A 03B 03C TU5A TU5B TU5C
BTRT	2	BLKED UNBLKED

Number of observations in data set = 163

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	11	1.16582107	6.31	0.0001
Error	151	2.53463205		
Corrected Total	162	3.70045312		

R-Square	C.V.	STP Mean
0.315048	85.42632	0.15166218

Source	DF	Type I SS	F Value	Pr > F
INTAKE	5	0.53117924	6.33	0.0001
BTRT	1	0.30419458	18.12	0.0001
INTAKE*BTRT	5	0.33044725	3.94	0.0022

Source	DF	Type III SS	F Value	Pr > F
INTAKE	5	0.52151976	6.21	0.0001
BTRT	1	0.27477541	16.37	0.0001
INTAKE*BTRT	5	0.33044725	3.94	0.0022

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE SPRING 96

---------------------------- INTAKE=03A ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 28

---------------------------- INTAKE=03A ----------------------------

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.17980409	14.15	0.0009
Error	26	0.33027749		
Corrected Total	27	0.51008158		

R-Square	C.V.	STP Mean
0.352501	69.23050	0.16280036

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.17980409	14.15	0.0009
Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.17980409	14.15	0.0009

---------------------------- INTAKE=03A ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.012703

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.24294	14	UNBLKED
B	0.08267	14	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE
SPRING 96

------------------------------ INTAKE=03B ------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 28

------------------------------ INTAKE=03B ------------------------------

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.12371866	2.92	0.0996
Error	26	1.10299556		
Corrected Total	27	1.22671422		

R-Square	C.V.	STP Mean
0.100854	87.90817	0.23429929

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.12371866	2.92	0.0996

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.12371866	2.92	0.0996

------------------------------ INTAKE=03B ------------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.042423

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.30077	14	UNBLKED
A			
A	0.16783	14	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE
SPRING 96

---------------------------- INTAKE=03C ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 28

---------------------------- INTAKE=03C ----------------------------

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.12789704	4.73	0.0390
Error	26	0.70362819		
Corrected Total	27	0.83152523		

R-Square	C.V.	STP Mean
0.153810	84.08805	0.19563686

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.12789704	4.73	0.0390
Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.12789704	4.73	0.0390

---------------------------- INTAKE=03C ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.027063

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.26322	14	UNBLKED
B	0.12805	14	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE
SPRING 96

---------------------------- INTAKE=TU5A ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 28

---------------------------- INTAKE=TU5A ----------------------------

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.17159312	26.64	0.0001
Error	26	0.16744275		
Corrected Total	27	0.33903586		

R-Square	C.V.	STP Mean
0.506121	53.74893	0.14930578

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.17159312	26.64	0.0001
Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.17159312	26.64	0.0001

---------------------------- INTAKE=TU5A ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.00644

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.22759	14	UNBLKED
B	0.07102	14	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE
SPRING 96

---------------------------- INTAKE=TU5B ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 26

---------------------------- INTAKE=TU5B ----------------------------

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00399856	0.66	0.4246
Error	24	0.14540791		
Corrected Total	25	0.14940647		

R-Square	C.V.	STP Mean
0.026763	97.22733	0.08005713

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.00399856	0.66	0.4246

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.00399856	0.66	0.4246

---------------------------- INTAKE=TU5B ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 24 MSE= 0.006059
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 12.92308

Number of Means 2
Critical F 4.2596773

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.09345	12	BLKED
A			
A	0.06858	14	UNBLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE
SPRING 96

---------------------------- INTAKE=TU5C ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 25

---------------------------- INTAKE=TU5C ----------------------------

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.02763036	7.49	0.0118
Error	23	0.08488015		
Corrected Total	24	0.11251051		

R-Square	C.V.	STP Mean
0.245580	81.55253	0.07449064

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.02763036	7.49	0.0118
Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.02763036	7.49	0.0118

---------------------------- INTAKE=TU5C ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 23 MSE= 0.00369
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 12.48

Number of Means 2
Critical F 4.2793443

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.10909	12	BLKED
B	0.04255	13	UNBLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 3 & 5 Pooled)
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in data set = 163
General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.28519783	13.44	0.0003
Error	161	3.41525529		
Corrected Total	162	3.70045312		

R-Square	C.V.	STP Mean
0.077071	96.03319	0.15166218

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.28519783	13.44	0.0003

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.28519783	13.44	0.0003

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 161 MSE= 0.021213
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 81.47239

Number of Means	2
Critical F	3.899867

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.19273	83	UNBLKED
B	0.10906	80	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG INTAKES (Unit 3 & 5 Pooled)
SPRING 96

Class	Levels	Values
INTAKE	6	03A 03B 03C TU5A TU5B TU5C

Number of observations in data set = 163

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	5	0.53117924	5.26	0.0002
Error	157	3.16927388		
Corrected Total	162	3.70045312		

R-Square	C.V.	STP Mean
0.143544	93.68127	0.15166218

Source	DF	Type I SS	F Value	Pr > F
INTAKE	5	0.53117924	5.26	0.0002

Source	DF	Type III SS	F Value	Pr > F
INTAKE	5	0.53117924	5.26	0.0002

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 157 MSE= 0.020186
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 27.11023

Number of Means	2	3	4	5	6
Critical F	5.8248769	3.7635743	2.9708048	2.4292527	2.2717627

Means with the same letter are not significantly different.

REGWF Grouping		Mean	N	INTAKE
	A	0.23430	28	03B
	A			
	A	0.19564	28	03C
	A			
B	A	0.16280	28	03A
B	A			
B	A	0.14931	28	TU5A
B				
B		0.08006	26	TU5B
B				
B		0.07449	25	TU5C

TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG TREATMENTS AND UNITS FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	3	BO UC UO
UNIT	2	3 5

Number of observations in data set = 43

NOTE: Due to missing values, only 41 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	7409.9813664	1481.9962733	1.54	0.2035
Error	35	33731.4282653	963.7550933		
Corrected Total	40	41141.4096317			

R-Square	C.V.	Root MSE	FPE Mean
0.180110	49.97340	31.044405	62.121858

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	2	3141.6154043	1570.8077022	1.63	0.2105
UNIT	1	349.4703006	349.4703006	0.36	0.5509
TREAT*UNIT	2	3918.8956615	1959.4478307	2.03	0.1461

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	2	3202.5658946	1601.2829473	1.66	0.2045
UNIT	1	392.9294956	392.9294956	0.41	0.5273
TREAT*UNIT	2	3918.8956615	1959.4478307	2.03	0.1461

TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) FOR Unit 3 & 5 Pooled
FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	3	BO UC UO

Number of observations in data set = 43
NOTE: Due to missing values, only 41 observations can be used in this analysis.

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	3141.6154043	1570.8077022	1.57	0.2211
Error	38	37999.7942274	999.9945849		
Corrected Total	40	41141.4096317			

R-Square	C.V.	Root MSE	FPE Mean
0.076361	50.90429	31.622691	62.121858

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	2	3141.6154043	1570.8077022	1.57	0.2211

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	2	3141.6154043	1570.8077022	1.57	0.2211

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 38 MSE= 999.9946
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.65

Number of Means	2	3
Critical F	4.0981717	3.2448184

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	71.89	13	UO
A			
A	64.47	14	UC
A			
A	50.71	14	BO

TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG BLK TREATMENTS AND UNITS FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED
UNIT	2	3 5

Number of observations in data set = 43
NOTE: Due to missing values, only 41 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	6643.1109597	2214.3703199	2.37	0.0857
Error	37	34498.2986720	932.3864506		
Corrected Total	40	41141.4096317			

R-Square	C.V.	Root MSE	FPE Mean
0.161470	49.15340	30.535004	62.121858

Source	DF	Type I SS	Mean Square	F Value	Pr > F
BTRT	1	2770.8518206	2770.8518206	2.97	0.0931
UNIT	1	285.7106173	285.7106173	0.31	0.5832
BTRT*UNIT	1	3586.5485219	3586.5485219	3.85	0.0574

Source	DF	Type III SS	Mean Square	F Value	Pr > F
BTRT	1	2659.6233256	2659.6233256	2.85	0.0996
UNIT	1	8.5120889	8.5120889	0.01	0.9244
BTRT*UNIT	1	3586.5485219	3586.5485219	3.85	0.0574

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG BLOCK TREATMENTS (Unit 3 & 5 Pool
FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in data set = 43
NOTE: Due to missing values, only 41 observations can be used in this analysis.

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2770.8518206	2770.8518206	2.82	0.1013
Error	39	38370.5578111	983.8604567		
Corrected Total	40	41141.4096317			

R-Square	C.V.	Root MSE	FPE Mean
0.067349	50.49197	31.366550	62.121858

Source	DF	Type I SS	Mean Square	F Value	Pr > F
BTRT	1	2770.8518206	2770.8518206	2.82	0.1013

Source	DF	Type III SS	Mean Square	F Value	Pr > F
BTRT	1	2770.8518206	2770.8518206	2.82	0.1013

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 39 MSE= 983.8605
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 18.43902

Number of Means	2
Critical F	4.0912786

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	68.04	27	UNBLKED
A			
A	50.71	14	BLKED

TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS AND UNITS FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED
UNIT	2	3 5

Number of observations in data set = 43
NOTE: Due to missing values, only 41 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2305.3928207	768.4642736	0.73	0.5395
Error	37	38836.0168110	1049.6220760		
Corrected Total	40	41141.4096317			

R-Square	C.V.	Root MSE	FPE Mean
0.056036	52.15213	32.397871	62.121858

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	117.2832942	117.2832942	0.11	0.7401
UNIT	1	287.7397307	287.7397307	0.27	0.6037
GTRT*UNIT	1	1900.3697958	1900.3697958	1.81	0.1866

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	32.8045628	32.8045628	0.03	0.8606
UNIT	1	914.2378078	914.2378078	0.87	0.3567
GTRT*UNIT	1	1900.3697958	1900.3697958	1.81	0.1866

ONE-WAY ANOVA ON FPE [(GUIDED
+ SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 3 & 5 Poole
FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 43
NOTE: Due to missing values, only 41 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	117.28329423	117.28329423	0.11	0.7402
Error	39	41024.12633748	1051.90067532		
Corrected Total	40	41141.40963171			

R-Square	C.V.	Root MSE	FPE Mean
0.002851	52.20871	32.433018	62.121858

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	117.28329423	117.28329423	0.11	0.7402

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	117.28329423	117.28329423	0.11	0.7402

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 39 MSE= 1051.901
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 18.43902

Number of Means	2
Critical F	4.0912786

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	64.47	14	CLOSED
A			
A	60.90	27	OPEN

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 3)
FOR SUMMED DATA
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2415.9803790	2415.9803790	1.48	0.2348
Error	26	42453.0320186	1632.8089238		
Corrected Total	27	44869.0123976			

R-Square	C.V.	Root MSE	FPE Mean
0.053845	83.09461	40.408030	48.628941

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	2415.9803790	2415.9803790	1.48	0.2348

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	2415.9803790	2415.9803790	1.48	0.2348

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 1632.809
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.92857

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	58.61	13	OPEN
A			
A	39.98	15	CLOSED

ONE-WAY ANOVA ON FPE [(GUIDED
+ SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 5)
FOR SUMMED DATA
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 28
NOTE: Due to missing values, only 25 observations can be used in this analysis.

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	7764.6578869	7764.6578869	7.35	0.0125
Error	23	24312.6227923	1057.0705562		
Corrected Total	24	32077.2806792			

R-Square	C.V.	Root MSE	FPE Mean
0.242061	68.56970	32.512621	47.415434

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	7764.6578869	7764.6578869	7.35	0.0125

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	7764.6578869	7764.6578869	7.35	0.0125

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 23 MSE= 1057.071
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 12.32

Number of Means	2
Critical F	4.2793443

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	63.04	14	OPEN
B	27.53	11	CLOSED

ONE-WAY ANOVA ON FGE [(GUIDED / (GUIDED + UNGUIDED) AMONG UNITS FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
UNIT	2	3 5

Number of observations in data set = 28
NOTE: Due to missing values, only 27 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	5672.5172027	5672.5172027	40.30	0.0001
Error	25	3518.9653743	140.7586150		
Corrected Total	26	9191.4825770			

R-Square	C.V.	Root MSE	FGE Mean
0.617149	19.82755	11.864174	59.836822

Source	DF	Type I SS	Mean Square	F Value	Pr > F
UNIT	1	5672.5172027	5672.5172027	40.30	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
UNIT	1	5672.5172027	5672.5172027	40.30	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 25 MSE= 140.7586
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.48148

Number of Means	2
Critical F	4.2416991

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	UNIT
A	73.804	14	3
B	44.795	13	5

TWO-WAY ANOVA ON IN-TURBINE FGE
AMONG GATE TREATMENTS (Unit 3 & 5 Pooled)
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED
INTAKE	6	03A 03B 03C TU5A TU5B TU5C

Number of observations in data set = 83

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	40163.553770	3651.232161	11.64	0.0001
Error	71	22264.232746	313.580743		
Corrected Total	82	62427.786516			

R-Square	C.V.	Root MSE	FGE Mean
0.643360	32.63593	17.708211	54.259865

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	744.586440	744.586440	2.37	0.1278
INTAKE	5	38356.120072	7671.224014	24.46	0.0001
GTRT*INTAKE	5	1062.847258	212.569452	0.68	0.6416

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	171.473562	171.473562	0.55	0.4621
INTAKE	5	38148.229102	7629.645820	24.33	0.0001
GTRT*INTAKE	5	1062.847258	212.569452	0.68	0.6416

ONE-WAY ANOVA ON IN-TURBINE FGE
AMONG INTAKES (Unit 3 & 5 Pooled)
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	6	03A 03B 03C TU5A TU5B TU5C

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	38916.491812	7783.298362	25.49	0.0001
Error	77	23511.294704	305.341490		
Corrected Total	82	62427.786516			

R-Square	C.V.	Root MSE	FGE Mean
0.623384	32.20433	17.474023	54.259865

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTAKE	5	38916.491812	7783.298362	25.49	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTAKE	5	38916.491812	7783.298362	25.49	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 77 MSE= 305.3415
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.82278

Number of Means	2	3	4	5	6
Critical F	5.9574231	3.8573667	3.0480784	2.4904465	2.3333079

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	INTAKE
A	86.444	14	03A
B	65.860	14	03B
B			
B	63.296	14	03C
B			
B	53.836	14	TU5A
C	34.710	13	TU5C
C			
C	20.016	14	TU5B

ONE-WAY ANOVA ON IN-TURBINE FGE
AMONG GATE TREATMENTS (Unit 3 & 5 Pooled)
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 83

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	744.58644023	744.58644023	0.98	0.3257
Error	81	61683.20007601	761.52098859		
Corrected Total	82	62427.78651623			

R-Square	C.V.	Root MSE	FGE Mean
0.011927	50.85835	27.595670	54.259865

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	744.58644023	744.58644023	0.98	0.3257

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	744.58644023	744.58644023	0.98	0.3257

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 81 MSE= 761.521
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 41.3494

Number of Means	2
Critical F	3.9588517

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	57.080	44	CLOSED
A			
A	51.079	39	OPEN

ONE-WAY ANOVA ON IN-TURBINE FGE BY UNIT
AMONG GATE TREATMENTS (SUMMED DATA)
SPRING 96

------------------------------------ UNIT=3 ------------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in by group = 14

------------------------------------ UNIT=3 ------------------------------------

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	25.15779747	25.15779747	0.43	0.5236
Error	12	699.32919792	58.27743316		
Corrected Total	13	724.48699539			

R-Square	C.V.	Root MSE	FGE Mean
0.034725	10.34354	7.6339658	73.804161

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	25.15779747	25.15779747	0.43	0.5236

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	25.15779747	25.15779747	0.43	0.5236

------------------------------------ UNIT=3 ------------------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 12 MSE= 58.27743
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 6.857143

Number of Means	2
Critical F	4.7472253

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	74.965	8	CLOSED
A			
A	72.256	6	OPEN

ONE-WAY ANOVA ON IN-TURBINE FGE BY UNIT
AMONG GATE TREATMENTS (SUMMED DATA)
SPRING 96

------------------------------------ UNIT=5 ------------------------------------

Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in by group = 14

NOTE: Due to missing values, only 13 observations can be used in this analysis.

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	359.87447253	359.87447253	1.63	0.2285
Error	11	2434.60390642	221.32762786		
Corrected Total	12	2794.47837895			

R-Square	C.V.	Root MSE	FGE Mean
0.128781	33.21143	14.877084	44.795072

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	359.87447253	359.87447253	1.63	0.2285

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	359.87447253	359.87447253	1.63	0.2285

------------------------------------ UNIT=5 ------------------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 11 MSE= 221.3276
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 6.461538

Number of Means	2
Critical F	4.8443357

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	50.478	6	CLOSED
A			
A	39.924	7	OPEN

TWO-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE / BYPASSED] AMONG TREATMENTS AND UNITS FOR SUMMED DATA SETS SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO
UNIT	2	3 5

Number of observations in data set = 26

NOTE: Due to missing values, only 25 observations can be used in this analysis.

Dependent Variable: SSP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.10641856	0.03547285	0.90	0.4572
Error	21	0.82665376	0.03936446		
Corrected Total	24	0.93307232			

R-Square	C.V.	Root MSE	SSP Mean
0.114052	279.3589	0.1984048	0.0710215

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.05212343	0.05212343	1.32	0.2628
UNIT	1	0.03030355	0.03030355	0.77	0.3902
TREAT*UNIT	1	0.02399158	0.02399158	0.61	0.4437

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.04646293	0.04646293	1.18	0.2896
UNIT	1	0.02829897	0.02829897	0.72	0.4061
TREAT*UNIT	1	0.02399158	0.02399158	0.61	0.4437

ONE-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE / BYPASSED] AMONG TREATMENTS (Unit 3 & 5 Pooled)
FOR SUMMED DATA SETS
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 26

NOTE: Due to missing values, only 25 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: SSP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.05212343	0.05212343	1.36	0.2553
Error	23	0.88094889	0.03830213		
Corrected Total	24	0.93307232			

R-Square	C.V.	Root MSE	SSP Mean
0.055862	275.5636	0.1957093	0.0710215

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.05212343	0.05212343	1.36	0.2553

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.05212343	0.05212343	1.36	0.2553

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SSP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 23 MSE= 0.038302
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 12.48

Number of Means 2
Critical F 4.2793443

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.11489	13	BO
A			
A	0.02350	12	UO

ONE-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE /BYPASSED] AMONG TREATMENTS (Unit 3)
FOR SUMMED DATA
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 13

General Linear Models Procedure

Dependent Variable: SSP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.07125369	0.07125369	0.95	0.3498
Error	11	0.82194852	0.07472259		
Corrected Total	12	0.89320221			

R-Square	C.V.	Root MSE	SSP Mean
0.079773	257.5559	0.2733543	0.1061340

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.07125369	0.07125369	0.95	0.3498

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.07125369	0.07125369	0.95	0.3498

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SSP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 11 MSE= 0.074723
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 6.461538

Number of Means	2
Critical F	4.8443357

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.1747	7	BO
A			
A	0.0262	6	UO

ONE-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE
/BYPASSED] AMONG TREATMENTS (Unit 5)
FOR SUMMED DATA
SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 13

NOTE: Due to missing values, only 12 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: SSP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.00177414	0.00177414	3.77	0.0808
Error	10	0.00470524	0.00047052		
Corrected Total	11	0.00647937			

R-Square	C.V.	Root MSE	SSP Mean
0.273813	65.76606	0.0216916	0.0329829

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.00177414	0.00177414	3.77	0.0808

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.00177414	0.00177414	3.77	0.0808

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SSP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 10 MSE= 0.000471

Number of Means	2
Critical F	4.9646027

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.04514	6	BO
A			
A	0.02082	6	UO

TWO-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE]
AMONG TREATMENTS AND UNITS IN SPRING 1996

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO
UNIT	2	3 5

Number of observations in data set = 26

NOTE: Due to missing values, only 25 observations can be used in this analysis.

Dependent Variable: SPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	16154.995255	5384.998418	4.65	0.0121
Error	21	24333.055793	1158.716943		
Corrected Total	24	40488.051048			

R-Square	C.V.	Root MSE	SPE Mean
0.399006	59.56435	34.039932	57.148165

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	866.833432	866.833432	0.75	0.3969
UNIT	1	15282.783954	15282.783954	13.19	0.0016
TREAT*UNIT	1	5.377868	5.377868	0.00	0.9463

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	1160.469545	1160.469545	1.00	0.3283
UNIT	1	15283.048715	15283.048715	13.19	0.0016
TREAT*UNIT	1	5.377868	5.377868	0.00	0.9463

ONE-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE]
AMONG TREATMENTS IN SPRING 1996 (Unit 3)

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 13

General Linear Models Procedure

Dependent Variable: SLU_FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	687.38134112	687.38134112	0.33	0.5798
Error	11	23228.88658053	2111.71696187		
Corrected Total	12	23916.26792166			

R-Square	C.V.	Root MSE	SLU_FGE Mean
0.028741	136.6498	45.953422	33.628600

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	687.38134112	687.38134112	0.33	0.5798

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	687.38134112	687.38134112	0.33	0.5798

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SLU_FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 11 MSE= 2111.717
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 6.461538

Number of Means	2
Critical F	4.8443357

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	40.36	7	BO
A			
A	25.77	6	UO

ONE-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE]
AMONG TREATMENTS IN SPRING 96 (Unit 5)

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 13

NOTE: Due to missing values, only 12 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: SLU_FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	485.92733155	485.92733155	4.40	0.0623
Error	10	1104.16921255	110.41692125		
Corrected Total	11	1590.09654410			

R-Square	C.V.	Root MSE	SLU_FGE Mean
0.305596	12.71722	10.507946	82.627695

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	485.92733155	485.92733155	4.40	0.0623

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	485.92733155	485.92733155	4.40	0.0623

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SLU_FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 10 MSE= 110.4169

Number of Means	2
Critical F	4.9646027

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	88.991	6	BO
A			
A	76.264	6	UO

Appendix B
Statistical Tests on Powerhouse 1 Data from Summer 1996

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS AND UNITS FOR SUMMED DATA SETS
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED
UNIT	2	3 5

Number of observations in data set = 60

NOTE: Due to missing values, only 59 observations can be used in this analysis.

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	2.15497507	26.98	0.0001
Error	55	1.46438928		
Corrected Total	58	3.61936435		

R-Square	C.V.	STP Mean
0.595402	66.35877	0.24589438

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.27815169	10.45	0.0021
UNIT	1	1.08534616	40.76	0.0001
BTRT*UNIT	1	0.79147723	29.73	0.0001

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.21634315	8.13	0.0061
UNIT	1	1.05688729	39.69	0.0001
BTRT*UNIT	1	0.79147723	29.73	0.0001

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS AND UNITS FOR SUMMED DATA SETS SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED
UNIT	2	3 5

Number of observations in data set = 60

NOTE: Due to missing values, only 59 observations can be used in this analysis.

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	1.12535298	8.27	0.0001
Error	55	2.49401137		
Corrected Total	58	3.61936435		

R-Square	C.V.	STP Mean
0.310926	86.60027	0.24589438

Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.00010222	0.00	0.9623
UNIT	1	1.10888007	24.45	0.0001
GTRT*UNIT	1	0.01637070	0.36	0.5504

Source	DF	Type III SS	F Value	Pr > F
GTRT	1	0.00519271	0.11	0.7364
UNIT	1	1.11111073	24.50	0.0001
GTRT*UNIT	1	0.01637070	0.36	0.5504

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED
TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED
+ UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS AND BLOCK TREATMENTS
FOR SUMMED DATA SETS
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED
GTRT	2	OPEN CLOSED

Number of observations in data set = 60
NOTE: Due to missing values, only 59 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.28338749	1.56	0.2101
Error	55	3.33597686		
Corrected Total	58	3.61936435		

R-Square	C.V.	STP Mean
0.078298	100.1571	0.24589438

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.27815169	4.59	0.0367
GTRT	1	0.00304368	0.05	0.8236
BTRT*GTRT	1	0.00219212	0.04	0.8499

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.27998275	4.62	0.0361
GTRT	1	0.00293951	0.05	0.8266
BTRT*GTRT	1	0.00219212	0.04	0.8499

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 3)
FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	4	BC BO UC UO

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	0.25686969	6.54	0.0022
Error	24	0.31423866		
Corrected Total	27	0.57110834		

R-Square	C.V.	STP Mean
0.449774	64.96691	0.17612945

Source	DF	Type I SS	F Value	Pr > F
TREAT	3	0.25686969	6.54	0.0022

Source	DF	Type III SS	F Value	Pr > F
TREAT	3	0.25686969	6.54	0.0022

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 24 MSE= 0.013093
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 6.927835

Number of Means	2	3	4
Critical F	5.6887853	3.4028261	3.0087866

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.27410	7	UC
A			
A	0.26925	7	UO
B	0.09113	6	BC
B			
B	0.07267	8	BO

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS (Unit 3)
FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.25561998	21.07	0.0001
Error	26	0.31548836		
Corrected Total	27	0.57110834		

R-Square	C.V.	STP Mean
0.447586	62.54218	0.17612945

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.25561998	21.07	0.0001

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.25561998	21.07	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.012134

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.27168	14	UNBLKED
B	0.08058	14	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS (Unit 3)
FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00443705	0.20	0.6556
Error	26	0.56667129		
Corrected Total	27	0.57110834		

R-Square	C.V.	STP Mean
0.007769	83.81986	0.17612945

Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.00443705	0.20	0.6556

Source	DF	Type III SS	F Value	Pr > F
GTRT	1	0.00443705	0.20	0.6556

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.021795
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.92857

Number of Means 2
Critical F 4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	0.18965	13	CLOSED
A			
A	0.16441	15	OPEN

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG TREATMENTS (Unit 5)
FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	4	BC BO UC UO

Number of observations in data set = 32
NOTE: Due to missing values, only 31 observations can be used in this analysis.

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	3	2.88804882	6.44	0.0020
Error	27	4.03890072		
Corrected Total	30	6.92694953		

R-Square	C.V.	STP Mean
0.416929	59.61900	0.64873157

Source	DF	Type I SS	F Value	Pr > F
TREAT	3	2.88804882	6.44	0.0020

Source	DF	Type III SS	F Value	Pr > F
TREAT	3	2.88804882	6.44	0.0020

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 27 MSE= 0.149589
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 7.578947

Number of Means	2	3	4
Critical F	5.6059779	3.3541308	2.9603513

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.9667	8	BO
A			
A	0.9209	8	BC
B	0.3403	6	UO
B			
B	0.3297	9	UC

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG BLK TREATMENTS (Unit 5)
FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in data set = 32

NOTE: Due to missing values, only 31 observations can be used in this analysis.

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	2.87925063	20.63	0.0001
Error	29	4.04769890		
Corrected Total	30	6.92694953		

R-Square	C.V.	STP Mean
0.415659	57.58907	0.64873157

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	2.87925063	20.63	0.0001

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	2.87925063	20.63	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 29 MSE= 0.139576
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 15.48387

Number of Means	2
Critical F	4.1829643

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.9438	16	BLKED
B	0.3340	15	UNBLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG GATE TREATMENTS (Unit 5)
FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 32

NOTE: Due to missing values, only 31 observations can be used in this analysis

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.06264684	0.26	0.6108
Error	29	6.86430270		
Corrected Total	30	6.92694953		

R-Square	C.V.	STP Mean
0.009044	74.99532	0.64873157

Source	DF	Type I SS	F Value	Pr > F
GTRT	1	0.06264684	0.26	0.6108

Source	DF	Type III SS	F Value	Pr > F
GTRT	1	0.06264684	0.26	0.6108

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 29 MSE= 0.2367
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 15.35484

Number of Means	2
Critical F	4.1829643

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	0.6983	14	OPEN
A			
A	0.6079	17	CLOSED

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS AND INTAKES
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	6	03A 03B 03C TU5A TU5B TU5C
BTRT	2	BLKED UNBLKED

Number of observations in data set = 176
NOTE: Due to missing values, only 173 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	11	3.89685304	38.00	0.0001
Error	161	1.50076038		
Corrected Total	172	5.39761342		

R-Square	C.V.	STP Mean
0.721959	105.1542	0.09181549

Source	DF	Type I SS	F Value	Pr > F
INTAKE	5	2.22394931	47.72	0.0001
BTRT	1	0.11979232	12.85	0.0004
INTAKE*BTRT	5	1.55311141	33.32	0.0001

Source	DF	Type III SS	F Value	Pr > F
INTAKE	5	2.10988551	45.27	0.0001
BTRT	1	0.09306534	9.98	0.0019
INTAKE*BTRT	5	1.55311141	33.32	0.0001

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE
SUMMER 96

---------------------------- INTAKE=03A ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 28

---------------------------- INTAKE=03A ----------------------------

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.01162329	22.05	0.0001
Error	26	0.01370725		
Corrected Total	27	0.02533053		

R-Square	C.V.	STP Mean
0.458865	62.62149	0.03666613

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.01162329	22.05	0.0001

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.01162329	22.05	0.0001

---------------------------- INTAKE=03A ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.000527

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.057041	14	UNBLKED
B	0.016292	14	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE
SUMMER 96

---------------------------- INTAKE=03B ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 28

---------------------------- INTAKE=03B ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00263597	4.03	0.0553
Error	26	0.01702510		
Corrected Total	27	0.01966106		

R-Square	C.V.	STP Mean
0.134070	87.37143	0.02928793

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.00263597	4.03	0.0553

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.00263597	4.03	0.0553

---------------------------- INTAKE=03B ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.000655

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.038991	14	UNBLKED
A			
A	0.019585	14	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE
SUMMER 96

---------------------------- INTAKE=03C ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 28

---------------------------- INTAKE=03C ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.02773204	26.87	0.0001
Error	26	0.02683632		
Corrected Total	27	0.05456837		

R-Square	C.V.	STP Mean
0.508207	67.63320	0.04750233

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.02773204	26.87	0.0001

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.02773204	26.87	0.0001

---------------------------- INTAKE=03C ----------------------------

General Linear Models Procedure

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.001032

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.07897	14	UNBLKED
B	0.01603	14	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE
SUMMER 96

---------------------------- INTAKE=TU5A ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 32
NOTE: Due to missing values, only 31 observations can be used in this analysis.

---------------------------- INTAKE=TU5A ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	1.61278409	33.60	0.0001
Error	29	1.39197824		
Corrected Total	30	3.00476233		

R-Square	C.V.	STP Mean
0.536743	65.55953	0.33418073

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	1.61278409	33.60	0.0001

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	1.61278409	33.60	0.0001

---------------------------- INTAKE=TU5A ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 29 MSE= 0.047999
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 15.48387

Number of Means 2
Critical F 4.1829643

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.55503	16	BLKED
B	0.09861	15	UNBLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE
SUMMER 96

---------------------------- INTAKE=TU5B ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 30
NOTE: Due to missing values, only 29 observations can be used in this analysis.

---------------------------- INTAKE=TU5B ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.01795108	14.08	0.0008
Error	27	0.03441554		
Corrected Total	28	0.05236662		

R-Square	C.V.	STP Mean
0.342796	95.12209	0.03753307

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.01795108	14.08	0.0008

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.01795108	14.08	0.0008

---------------------------- INTAKE=TU5B ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 27 MSE= 0.001275
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 14.48276

Number of Means 2
Critical F 4.2100085

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.06329	14	UNBLKED
B	0.01350	15	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED + UNGUIDED/BYPASSED) AT TEST TURBINES AMONG BLK TREATMENTS BY INTAKE
SUMMER 96

--------------------------- INTAKE=TU5C ---------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BTRT	2	BLKED UNBLKED

Number of observations in by group = 30
NOTE: Due to missing values, only 29 observations can be used in this analysis.

--------------------------- INTAKE=TU5C ---------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00017726	0.28	0.5979
Error	27	0.01679793		
Corrected Total	28	0.01697520		

R-Square	C.V.	STP Mean
0.010442	57.44278	0.04342208

Source	DF	Type I SS	F Value	Pr > F
BTRT	1	0.00017726	0.28	0.5979

Source	DF	Type III SS	F Value	Pr > F
BTRT	1	0.00017726	0.28	0.5979

--------------------------- INTAKE=TU5C ---------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 27 MSE= 0.000622
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 14.48276

Number of Means 2
Critical F 4.2100085

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	BTRT
A	0.045981	14	UNBLKED
A			
A	0.041034	15	BLKED

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED + UNGUIDED)/BYPASSED] AMONG INTAKES (Unit 3 & 5 Pooled)
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	6	03A 03B 03C TU5A TU5B TU5C

Number of observations in data set = 176
NOTE: Due to missing values, only 173 observations can be used in this analysis.

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	5	2.22394931	23.41	0.0001
Error	167	3.17366411		
Corrected Total	172	5.39761342		

R-Square	C.V.	STP Mean
0.412025	150.1434	0.09181549

Source	DF	Type I SS	F Value	Pr > F
INTAKE	5	2.22394931	23.41	0.0001

Source	DF	Type III SS	F Value	Pr > F
INTAKE	5	2.22394931	23.41	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 167 MSE= 0.019004
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 28.79542

Number of Means	2	3	4	5	6
Critical F	5.8173679	3.7582612	2.9664246	2.4257772	2.2682669

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	INTAKE
A	0.33418	31	TU5A
B	0.04750	28	03C
B			
B	0.04342	29	TU5C
B			
B	0.03753	29	TU5B
B			
B	0.03667	28	03A
B			
B	0.02929	28	03B

TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG TREATMENTS AND UNITS FOR SUMMED DATA SETS
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	3	BO UC UO
UNIT	2	3 5

Number of observations in data set = 46

General Linear Models Procedure

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	20224.331535	4044.866307	17.34	0.0001
Error	40	9329.938037	233.248451		
Corrected Total	45	29554.269572			

R-Square	C.V.	Root MSE	FPE Mean
0.684312	26.85461	15.272474	56.870951

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	2	8865.9011219	4432.9505610	19.01	0.0001
UNIT	1	6982.1622772	6982.1622772	29.93	0.0001
TREAT*UNIT	2	4376.2681358	2188.1340679	9.38	0.0005

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	2	8386.2872024	4193.1436012	17.98	0.0001
UNIT	1	6840.9850317	6840.9850317	29.33	0.0001
TREAT*UNIT	2	4376.2681358	2188.1340679	9.38	0.0005

TWO-WAY ANOVA ON FPE [(GUIDED
+ SLUICE) / (GUIDED + SLUICE + UNGUIDED) FOR Unit 3 & 5 Pooled
FOR SUMMED DATA SETS
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	3	BO UC UO

Number of observations in data set = 46

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	8865.9011219	4432.9505610	9.21	0.0005
Error	43	20688.3684502	481.1248477		
Corrected Total	45	29554.2695721			

R-Square	C.V.	Root MSE	FPE Mean
0.299987	38.56900	21.934558	56.870951

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	2	8865.9011219	4432.9505610	9.21	0.0005

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	2	8865.9011219	4432.9505610	9.21	0.0005

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 43 MSE= 481.1248
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 15.13267

Number of Means	2	3
Critical F	4.0670474	3.2144803

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	77.766	13	UO
B	53.856	17	UC
B			
B	43.097	16	BO

ONE-WAY ANOVA ON FPE [(GUIDED
+ SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG TREATMENTS (Unit 3)
FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	4	BC BO UC UO

Number of observations in data set = 28

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	26689.461394	8896.487131	61.08	0.0001
Error	24	3495.953905	145.664746		
Corrected Total	27	30185.415300			

R-Square	C.V.	Root MSE	FPE Mean
0.884184	21.83587	12.069165	55.272195

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	3	26689.461394	8896.487131	61.08	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	26689.461394	8896.487131	61.08	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 24 MSE= 145.6647
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 6.927835

Number of Means	2	3	4
Critical F	5.6887853	3.4028261	3.0087866

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	86.976	7	UO
B	68.100	8	BO
B			
B	56.285	7	UC
C	0.000	6	BC

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG TREATMENTS (Unit 5)
FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	4	BC BO UC UO

Number of observations in data set = 32

General Linear Models Procedure

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	21098.439850	7032.813283	33.75	0.0001
Error	28	5833.984132	208.356576		
Corrected Total	31	26932.423982			

R-Square	C.V.	Root MSE	FPE Mean
0.783384	43.23172	14.434562	33.388822

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	3	21098.439850	7032.813283	33.75	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	3	21098.439850	7032.813283	33.75	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 28 MSE= 208.3566
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 7.741935

Number of Means	2	3	4
Critical F	5.5826347	3.3403856	2.9466853

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	67.022	6	UO
A			
A	52.155	10	UC
B	18.095	8	BO
C	0.000	8	BC

TWO-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS AND UNITS
FOR SUMMED DATA SETS
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED
UNIT	2	3 5

Number of observations in data set = 46

General Linear Models Procedure

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	10686.767375	3562.255792	7.93	0.0003
Error	42	18867.502197	449.226243		
Corrected Total	45	29554.269572			

R-Square	C.V.	Root MSE	FPE Mean
0.361598	37.26851	21.194958	56.870951

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	245.1920176	245.1920176	0.55	0.4641
UNIT	1	7457.6971106	7457.6971106	16.60	0.0002
GTRT*UNIT	1	2983.8782467	2983.8782467	6.64	0.0136

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	148.9356325	148.9356325	0.33	0.5678
UNIT	1	4624.8864057	4624.8864057	10.30	0.0026
GTRT*UNIT	1	2983.8782467	2983.8782467	6.64	0.0136

ONE-WAY ANOVA ON FPE [(GUIDED
+ SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 3 & 5 Poole
FOR SUMMED DATA SETS
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 46

General Linear Models Procedure

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	245.19201756	245.19201756	0.37	0.5472
Error	44	29309.07755457	666.11539897		
Corrected Total	45	29554.26957214			

R-Square	C.V.	Root MSE	FPE Mean
0.008296	45.38206	25.809212	56.870951

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	245.19201756	245.19201756	0.37	0.5472

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	245.19201756	245.19201756	0.37	0.5472

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 44 MSE= 666.1154
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 21.43478

Number of Means	2
Critical F	4.0617065

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	58.639	29	OPEN
A			
A	53.856	17	CLOSED

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 3)
FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 28

General Linear Models Procedure

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	15124.265188	15124.265188	26.11	0.0001
Error	26	15061.150112	579.275004		
Corrected Total	27	30185.415300			

R-Square	C.V.	Root MSE	FPE Mean
0.501045	43.54474	24.068133	55.272195

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	15124.265188	15124.265188	26.11	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	15124.265188	15124.265188	26.11	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 579.275
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.92857

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	76.909	15	OPEN
B	30.307	13	CLOSED

ONE-WAY ANOVA ON FPE [(GUIDED + SLUICE) / (GUIDED + SLUICE + UNGUIDED) AMONG GATE TREATMENTS (Unit 5) FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 32

Dependent Variable: FPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	801.52248980	801.52248980	0.92	0.3451
Error	30	26130.90149200	871.03004973		
Corrected Total	31	26932.42398180			

R-Square	C.V.	Root MSE	FPE Mean
0.029761	88.39251	29.513218	33.388822

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	801.52248980	801.52248980	0.92	0.3451

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	801.52248980	801.52248980	0.92	0.3451

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 30 MSE= 871.03
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 15.75

Number of Means 2
Critical F 4.1708768

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	39.06	14	OPEN
A			
A	28.98	18	CLOSED

TWO-WAY ANOVA ON IN-TURBINE FGE
AMONG GATE TREATMENTS (Unit 3 & 5 Pooled)
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED
INTAKE	6	03A 03B 03C TU5A TU5B TU5C

Number of observations in data set = 87

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	7198.4900552	654.4081868	3.29	0.0010
Error	75	14924.9286779	198.9990490		
Corrected Total	86	22123.4187331			

R-Square	C.V.	Root MSE	FGE Mean
0.325379	25.45225	14.106702	55.424192

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	58.1935314	58.1935314	0.29	0.5903
INTAKE	5	6675.5442475	1335.1088495	6.71	0.0001
GTRT*INTAKE	5	464.7522762	92.9504552	0.47	0.7996

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	57.5634755	57.5634755	0.29	0.5923
INTAKE	5	7024.1252302	1404.8250460	7.06	0.0001
GTRT*INTAKE	5	464.7522762	92.9504552	0.47	0.7996

ONE-WAY ANOVA ON FGE [(GUIDED / (GUIDED + UNGUIDED) AMONG UNITS FOR SUMMED DATA SETS SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
UNIT	2	3 5

Number of observations in data set = 29

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	443.18281802	443.18281802	2.34	0.1378
Error	27	5116.73023161	189.50852710		
Corrected Total	28	5559.91304963			

R-Square	C.V.	Root MSE	FGE Mean
0.079710	25.93301	13.766210	53.083734

Source	DF	Type I SS	Mean Square	F Value	Pr > F
UNIT	1	443.18281802	443.18281802	2.34	0.1378

Source	DF	Type III SS	Mean Square	F Value	Pr > F
UNIT	1	443.18281802	443.18281802	2.34	0.1378

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 27 MSE= 189.5085
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 14.48276

Number of Means 2
Critical F 4.2100085

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	UNIT
A	57.130	14	3
A			
A	49.307	15	5

ONE-WAY ANOVA ON IN-TURBINE FGE
AMONG GATE TREATMENTS (Unit 3 & 5 Pooled)
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in data set = 87

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	58.19353145	58.19353145	0.22	0.6371
Error	85	22065.22520162	259.59088472		
Corrected Total	86	22123.41873307			

R-Square	C.V.	Root MSE	FGE Mean
0.002630	29.07002	16.111824	55.424192

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	58.19353145	58.19353145	0.22	0.6371

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	58.19353145	58.19353145	0.22	0.6371

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE
NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 85 MSE= 259.5909
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 43.03448

Number of Means	2
Critical F	3.9532093

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	56.161	48	CLOSED
A			
A	54.517	39	OPEN

ONE-WAY ANOVA ON IN-TURBINE FGE BY UNIT
AMONG GATE TREATMENTS (SUMMED DATA)
SUMMER 96

------------------------------------ UNIT=3 ------------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in by group = 14

------------------------------------ UNIT=3 ------------------------------------

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	10.00691863	10.00691863	0.86	0.3718
Error	12	139.47591774	11.62299315		
Corrected Total	13	149.48283637			

R-Square	C.V.	Root MSE	FGE Mean
0.066944	5.967513	3.4092511	57.130183

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	10.00691863	10.00691863	0.86	0.3718

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	10.00691863	10.00691863	0.86	0.3718

------------------------------------ UNIT=3 ------------------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE
NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 12 MSE= 11.62299

Number of Means	2
Critical F	4.7472253

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	57.976	7	OPEN
A			
A	56.285	7	CLOSED

ONE-WAY ANOVA ON IN-TURBINE FGE BY UNIT
AMONG GATE TREATMENTS (SUMMED DATA)
SUMMER 96

------------------------------------ UNIT=5 ------------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
GTRT	2	OPEN CLOSED

Number of observations in by group = 15

------------------------------------ UNIT=5 ------------------------------------

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	167.15028550	167.15028550	0.45	0.5128
Error	13	4800.09710974	369.23823921		
Corrected Total	14	4967.24739525			

R-Square	C.V.	Root MSE	FGE Mean
0.033650	38.97125	19.215573	49.307049

Source	DF	Type I SS	Mean Square	F Value	Pr > F
GTRT	1	167.15028550	167.15028550	0.45	0.5128

Source	DF	Type III SS	Mean Square	F Value	Pr > F
GTRT	1	167.15028550	167.15028550	0.45	0.5128

------------------------------------ UNIT=5 ------------------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE
NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 13 MSE= 369.2382
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 7.2

Number of Means 2
Critical F 4.6671927

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	GTRT
A	52.03	9	CLOSED
A			
A	45.22	6	OPEN

ONE-WAY ANOVA ON IN-TURBINE FGE
AMONG INTAKES (Unit 3 & 5 Pooled)
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	6	03A 03B 03C TU5A TU5B TU5C

Number of observations in data set = 87

Dependent Variable: FGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	6674.4989628	1334.8997926	7.00	0.0001
Error	81	15448.9197703	190.7274046		
Corrected Total	86	22123.4187331			

R-Square	C.V.	Root MSE	FGE Mean
0.301694	24.91766	13.810409	55.424192

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTAKE	5	6674.4989628	1334.8997926	7.00	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTAKE	5	6674.4989628	1334.8997926	7.00	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE
NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 81 MSE= 190.7274
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 14.48276

Number of Means	2	3	4	5	6
Critical F	5.9443883	3.8481424	3.040483	2.4844414	2.3272689

Means with the same letter are not significantly different.

REGWF Grouping		Mean	N	INTAKE
	A	64.364	14	03C
	A			
	A	62.875	15	TU5C
	A			
	A	61.702	15	TU5B
	A			
B	A	56.073	14	03A
B				
B	C	45.933	14	03B
	C			
	C	41.605	15	TU5A

TWO-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE / BYPASSED] AMONG TREATMENTS AND UNITS FOR SUMMED DATA SETS
SUMMER 96

General Linear Models Procedure

Dependent Variable: SSP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1.15896115	0.38632038	7.78	0.0008
Error	24	1.19181393	0.04965891		
Corrected Total	27	2.35077508			

R-Square	C.V.	Root MSE	SSP Mean
0.493012	86.18065	0.2228428	0.2585764

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.52305568	0.52305568	10.53	0.0034
UNIT	1	0.32610192	0.32610192	6.57	0.0171
TREAT*UNIT	1	0.30980354	0.30980354	6.24	0.0198

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.46001342	0.46001342	9.26	0.0056
UNIT	1	0.37177245	0.37177245	7.49	0.0115
TREAT*UNIT	1	0.30980354	0.30980354	6.24	0.0198

ONE-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE /BYPASSED] AMONG TREATMENTS (Unit 3)
FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 15

General Linear Models Procedure

Dependent Variable: SSP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.82171767	0.82171767	9.92	0.0077
Error	13	1.07656176	0.08281244		
Corrected Total	14	1.89827943			

R-Square	C.V.	Root MSE	SSP Mean
0.432875	80.00440	0.2877715	0.3596946

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.82171767	0.82171767	9.92	0.0077

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.82171767	0.82171767	9.92	0.0077

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SSP
NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 13 MSE= 0.082812
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 7.466667

Number of Means	2
Critical F	4.6671927

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.6099	7	UO
B	0.1408	8	BO

ONE-WAY ANOVA ON STANDARDIZED SLUICE PASSAGE [(SLUICE /BYPASSED] AMONG TREATMENTS (Unit 5)
FOR SUMMED DATA
SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 13

Dependent Variable: SSP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.00690052	0.00690052	0.66	0.4343
Error	11	0.11525218	0.01047747		
Corrected Total	12	0.12215270			

R-Square	C.V.	Root MSE	SSP Mean
0.056491	72.13422	0.1023595	0.1419015

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	0.00690052	0.00690052	0.66	0.4343

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	0.00690052	0.00690052	0.66	0.4343

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SSP
NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 11 MSE= 0.010477
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 6.461538

Number of Means 2
Critical F 4.8443357

Means with thesame letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.16679	6	UO
A			
A	0.12057	7	BO

TWO-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE]
AMONG TREATMENTS AND UNITS IN SUMMER 1996

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO
UNIT	2	3 5

Number of observations in data set = 28

TWO-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE]
AMONG TREATMENTS AND UNITS IN SUMMER 1996

General Linear Models Procedure

Dependent Variable: SPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	10529.400802	3509.800267	7.64	0.0009
Error	24	11027.723729	459.488489		
Corrected Total	27	21557.124531			

R-Square	C.V.	Root MSE	SPE Mean
0.488442	40.98355	21.435683	52.303143

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	973.8402087	973.8402087	2.12	0.1584
UNIT	1	8710.2800939	8710.2800939	18.96	0.0002
TREAT*UNIT	1	845.2804994	845.2804994	1.84	0.1876

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	1072.2599378	1072.2599378	2.33	0.1397
UNIT	1	8278.7148479	8278.7148479	18.02	0.0003
TREAT*UNIT	1	845.2804994	845.2804994	1.84	0.1876

ONE-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE]
AMONG TREATMENTS IN SUMMER 1996 (Unit 3)

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 15

Dependent Variable: SPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	7.26485699	7.26485699	0.01	0.9165
Error	13	8256.33596985	635.10276691		
Corrected Total	14	8263.60082683			

R-Square	C.V.	Root MSE	SPE Mean
0.000879	36.65598	25.201245	68.750701

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	7.26485699	7.26485699	0.01	0.9165

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	7.26485699	7.26485699	0.01	0.9165

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 13 MSE= 635.1028
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 7.466667

Number of Means 2
Critical F 4.6671927

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	69.49	7	UO
A			
A	68.10	8	BO

ONE-WAY ANOVA ON SLUICE FPE [(SLUICE / SLUICE + TURBINE]
AMONG TREATMENTS IN SUMMER 96 (Unit 5)

General Linear Models Procedure
Class Level Information

Class	Levels	Values
TREAT	2	BO UO

Number of observations in data set = 13

Dependent Variable: SPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1782.1883200	1782.1883200	7.07	0.0222
Error	11	2771.3877588	251.9443417		
Corrected Total	12	4553.5760788			

R-Square	C.V.	Root MSE	SPE Mean
0.391382	47.62990	15.872755	33.325190

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TREAT	1	1782.1883200	1782.1883200	7.07	0.0222

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TREAT	1	1782.1883200	1782.1883200	7.07	0.0222

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: SPE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 11 MSE= 251.9443
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 6.461538

Number of Means	2
Critical F	4.8443357

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	45.972	6	UO
B	22.485	7	BO

Appendix C
Statistical Tests on Powerhouse 2 Data from Spring 1996

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED & UNGUIDED & SLUICED/BYPASSED) AT TEST TURBINES AMONG INTAKES AND TREATMENTS
PH2 SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	8	TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18
CTREAT	2	C O

Number of observations in data set = 216

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	15	0.00602145	14.29	0.0001
Error	200	0.00561934		
Corrected Total	215	0.01164079		

R-Square	C.V.	STP Mean
0.517272	91.41359	0.00579852

Source	DF	Type I SS	F Value	Pr > F
INTAKE	7	0.00559390	28.44	0.0001
CTREAT	1	0.00007054	2.51	0.1147
INTAKE*CTREAT	7	0.00035701	1.82	0.0861

Source	DF	Type III SS	F Value	Pr > F
INTAKE	7	0.00569883	28.98	0.0001
CTREAT	1	0.00008069	2.87	0.0917
INTAKE*CTREAT	7	0.00035701	1.82	0.0861

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS
PH2 SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in data set = 216

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00004953	0.91	0.3400
Error	214	0.01159127		
Corrected Total	215	0.01164079		

R-Square	C.V.	STP Mean
0.004255	126.9234	0.00579852

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00004953	0.91	0.3400

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00004953	0.91	0.3400

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 214 MSE= 0.000054
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 107.9907

Number of Means 2
Critical F 3.8852796

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	CTREAT
A	0.006273	109	C
A			
A	0.005315	107	O

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96

--------------------------- INTAKE=TU11 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 25

--------------------------- INTAKE=TU11 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00040944	2.92	0.1009
Error	23	0.00322331		
Corrected Total	24	0.00363275		

R-Square	C.V.	STP Mean
0.112708	60.77298	0.01947943

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00040944	2.92	0.1009

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00040944	2.92	0.1009

--------------------------- INTAKE=TU11 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 23 MSE= 0.00014
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 12.48

Number of Means 2
Critical F 4.2793443

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	CTREAT
A	0.023692	12	C
A			
A	0.015591	13	O

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96

--------------------------- INTAKE=TU12 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 24

--------------------------- INTAKE=TU12 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00000144	0.16	0.6906
Error	22	0.00019514		
Corrected Total	23	0.00019659		

R-Square	C.V.	STP Mean
0.007342	117.6895	0.00253063

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00000144	0.16	0.6906

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00000144	0.16	0.6906

--------------------------- INTAKE=TU12 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 22 MSE= 8.87E-6
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 11.91667

Number of Means 2
Critical F 4.3009495

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	CTREAT
A	0.002756	13	C
A			
A	0.002264	11	O

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96

--------------------------- INTAKE=TU13 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 28

--------------------------- INTAKE=TU13 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00000395	0.22	0.6451
Error	26	0.00047342		
Corrected Total	27	0.00047737		

R-Square	C.V.	STP Mean
0.008283	124.9818	0.00341419

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00000395	0.22	0.6451

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00000395	0.22	0.6451

--------------------------- INTAKE=TU13 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.000018

Number of Means 2
Critical F 4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	CTREAT
A	0.003790	14	C
A			
A	0.003038	14	O

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96

--------------------------- INTAKE=TU14 ---------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 27

--------------------------- INTAKE=TU14 ---------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00000672	0.17	0.6796
Error	25	0.00096190		
Corrected Total	26	0.00096862		

R-Square	C.V.	STP Mean
0.006936	102.1838	0.00607034

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00000672	0.17	0.6796

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00000672	0.17	0.6796

--------------------------- INTAKE=TU14 ---------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 25 MSE= 0.000038
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.48148

Number of Means 2
Critical F 4.2416991

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.006551	14	C
A			
A	0.005553	13	O

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96

---------------------------- INTAKE=TU15 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 28

---------------------------- INTAKE=TU15 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00000097	0.33	0.5722
Error	26	0.00007736		
Corrected Total	27	0.00007833		

R-Square	C.V.	STP Mean
0.012431	72.81023	0.00236905

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00000097	0.33	0.5722

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00000097	0.33	0.5722

---------------------------- INTAKE=TU15 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 2.975E-6

Number of Means 2
Critical F 4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	CTREAT
A	0.0025555	14	O
A			
A	0.0021826	14	C

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96

---------------------------- INTAKE=TU16 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 28

---------------------------- INTAKE=TU16 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00000064	0.06	0.8159
Error	26	0.00030077		
Corrected Total	27	0.00030141		

R-Square	C.V.	STP Mean
0.002123	66.57986	0.00510841

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00000064	0.06	0.8159

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00000064	0.06	0.8159

---------------------------- INTAKE=TU16 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.000012

Number of Means 2
Critical F 4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	CTREAT
A	0.005260	14	O
A			
A	0.004957	14	C

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96

---------------------------- INTAKE=TU17 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 28

---------------------------- INTAKE=TU17 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00000167	0.23	0.6373
Error	26	0.00019039		
Corrected Total	27	0.00019205		

R-Square	C.V.	STP Mean
0.008675	57.48777	0.00470715

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00000167	0.23	0.6373

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00000167	0.23	0.6373

---------------------------- INTAKE=TU17 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 7.323E-6

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	CTREAT
A	0.004951	14	O
A			
A	0.004463	14	C

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS BY INTAKE AT PH2 SPRING 96

---------------------------- INTAKE=TU18 -----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 28

---------------------------- INTAKE=TU18 -----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00000271	0.36	0.5548
Error	26	0.00019706		
Corrected Total	27	0.00019977		

R-Square	C.V.	STP Mean
0.013585	74.05418	0.00371760

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00000271	0.36	0.5548

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00000271	0.36	0.5548

---------------------------- INTAKE=TU18 -----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 7.579E-6

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	CTREAT
A	0.004029	14	C
A			
A	0.003406	14	O

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG INTAKES
PH2 SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	8	TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18

Number of observations in data set = 216

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	7	0.00559390	27.49	0.0001
Error	208	0.00604689		
Corrected Total	215	0.01164079		

R-Square	C.V.	STP Mean
0.480543	92.98598	0.00579852

Source	DF	Type I SS	F Value	Pr > F
INTAKE	7	0.00559390	27.49	0.0001

Source	DF	Type III SS	F Value	Pr > F
INTAKE	7	0.00559390	27.49	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP
NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 208 MSE= 0.000029
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 26.9111

Number of Means	2	3	4	5
Critical F	6.3134752	4.0370093	3.1697188	2.703401

Number of Means	6	7	8
Critical F	2.4089733	2.1423641	2.0538082

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	INTAKE
A	0.019479	25	TU11
B	0.006070	27	TU14
B			
B	0.005108	28	TU16
B			
B	0.004707	28	TU17
B			
B	0.003718	28	TU18
B			
B	0.003414	28	TU13
B			
B	0.002531	24	TU12
B			
B	0.002369	28	TU15

TWO-WAY ANOVA ON FGE AMONG INTAKES AND TREATMENTS
PH2 SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	8	TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18
CTREAT	2	C O

Number of observations in data set = 216

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	15	51153.8078772	4.78	0.0001
Error	200	142574.4676714		
Corrected Total	215	193728.2755486		

R-Square	C.V.	FGE Mean
0.264049	71.90404	37.1323641

Source	DF	Type I SS	F Value	Pr > F
INTAKE	7	45084.2501986	9.03	0.0001
CTREAT	1	138.1022700	0.19	0.6603
INTAKE*CTREAT	7	5931.4554086	1.19	0.3108

Source	DF	Type III SS	F Value	Pr > F
INTAKE	7	44943.2237990	9.01	0.0001
CTREAT	1	125.3752390	0.18	0.6754
INTAKE*CTREAT	7	5931.4554086	1.19	0.3108

ONE-WAY ANOVA ON FGE
AMONG INTAKES
PH2 SPRING 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	8	TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18

Number of observations in data set = 216

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	7	45084.2501986	9.01	0.0001
Error	208	148644.0253500		
Corrected Total	215	193728.2755486		

R-Square	C.V.	FGE Mean
0.232719	71.99287	37.1323641

Source	DF	Type I SS	F Value	Pr > F
INTAKE	7	45084.2501986	9.01	0.0001

Source	DF	Type III SS	F Value	Pr > F
INTAKE	7	45084.2501986	9.01	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE
NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 208 MSE= 714.6347
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 26.9111

Number of Means	2	3	4	5
Critical F	6.3134752	4.0370093	3.1697188	2.703401

Number of Means	6	7	8
Critical F	2.4089733	2.1423641	2.0538082

Means with the same letter are not significantly different.

REGWF Grouping			Mean	N	INTAKE
	A		66.054	24	TU12
	A				
B	A		52.141	28	TU15
B					
B	C		40.375	28	TU13
B	C				
B	C		39.331	28	TU17
B	C				
B	C	D	30.376	28	TU18
	C	D			
	C	D	28.473	27	TU14
	C	D			
	C	D	26.301	28	TU16
		D			
		D	15.514	25	TU11

Appendix D
Statistical Tests on Powerhouse 2 Data from Summer 1996

TWO-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE (GUIDED & UNGUIDED & SLUICED/BYPASSED) AT TEST TURBINES AMONG INTAKES AND TREATMENTS
PH2 SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	8	TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18
CTREAT	2	C O

Number of observations in data set = 188

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	15	0.16730069	6.20	0.0001
Error	172	0.30951473		
Corrected Total	187	0.47681543		

	R-Square	C.V.	STP Mean
	0.350871	121.3089	0.03496904

Source	DF	Type I SS	F Value	Pr > F
INTAKE	7	0.14569558	11.57	0.0001
CTREAT	1	0.00214704	1.19	0.2762
INTAKE*CTREAT	7	0.01945807	1.54	0.1552

Source	DF	Type III SS	F Value	Pr > F
INTAKE	7	0.12988529	10.31	0.0001
CTREAT	1	0.00025369	0.14	0.7078
INTAKE*CTREAT	7	0.01945807	1.54	0.1552

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG INTAKES
PH2 SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	8	TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18

Number of observations in data set = 188

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	7	0.14569558	11.31	0.0001
Error	180	0.33111985		
Corrected Total	187	0.47681543		

R-Square	C.V.	STP Mean
0.305560	122.6514	0.03496904

Source	DF	Type I SS	F Value	Pr > F
INTAKE	7	0.14569558	11.31	0.0001

Source	DF	Type III SS	F Value	Pr > F
INTAKE	7	0.14569558	11.31	0.0001

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP
NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 180 MSE= 0.00184
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 17.00309

Number of Means	2	3	4	5
Critical F	6.3306494	4.0490667	3.1796455	2.7121273

Number of Means	6	7	8
Critical F	2.416915	2.1492492	2.0607618

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	INTAKE
A	0.18032	5	TU11
B	0.04987	27	TU14
B			
B	0.04841	27	TU12
B			
B	0.03780	24	TU13
B			
B	0.03217	21	TU18
B			
B	0.02119	28	TU16
B			

B	0.01987	28	TU17
B			
B	0.01023	28	TU15

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

---------------------------- INTAKE=TU11 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 5

---------------------------- INTAKE=TU11 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00985866	0.69	0.4662
Error	3	0.04266489		
Corrected Total	4	0.05252356		

R-Square	C.V.	STP Mean
0.187700	66.13545	0.18031854

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00985866	0.69	0.4662

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00985866	0.69	0.4662

---------------------------- INTAKE=TU11 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP
NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 3 MSE= 0.014222
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 2.4

Number of Means	2
Critical F	10.127964

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.2166	3	C
A			
A	0.1259	2	O

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED & UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS

PH2 SUMMER 96

---------------------------- INTAKE=TU12 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 27

---------------------------- INTAKE=TU12 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00032211	0.13	0.7248
Error	25	0.06354451		
Corrected Total	26	0.06386662		

R-Square	C.V.	STP Mean
0.005043	104.1387	0.04841241

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00032211	0.13	0.7248

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00032211	0.13	0.7248

---------------------------- INTAKE=TU12 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 25 MSE= 0.002542
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.48148

Number of Means 2
Critical F 4.2416991

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.05200	13	O
A			
A	0.04508	14	C

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED

& UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

--------------------------- INTAKE=TU13 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 24

--------------------------- INTAKE=TU13 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00749238	1.78	0.1954
Error	22	0.09244546		
Corrected Total	23	0.09993784		

R-Square	C.V.	STP Mean
0.074970	171.4855	0.03780107

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00749238	1.78	0.1954

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00749238	1.78	0.1954

--------------------------- INTAKE=TU13 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 22 MSE= 0.004202
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 11.91667

Number of Means 2
Critical F 4.3009495

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.05701	11	O
A			
A	0.02155	13	C

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED

& UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

---------------------------- INTAKE=TU14 -----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 27

---------------------------- INTAKE=TU14 -----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00376078	0.96	0.3354
Error	25	0.09746009		
Corrected Total	26	0.10122087		

R-Square	C.V.	STP Mean
0.037154	125.1990	0.04987037

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00376078	0.96	0.3354

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00376078	0.96	0.3354

---------------------------- INTAKE=TU14 -----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 25 MSE= 0.003898
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.48148

Number of Means 2
Critical F 4.2416991

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.06212	13	O
A			
A	0.03850	14	C

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED

& UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

---------------------------- INTAKE=TU15 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 28

---------------------------- INTAKE=TU15 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00001142	0.31	0.5845
Error	26	0.00096860		
Corrected Total	27	0.00098003		

R-Square	C.V.	STP Mean
0.011657	59.64290	0.01023357

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00001142	0.31	0.5845

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00001142	0.31	0.5845

---------------------------- INTAKE=TU15 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.000037

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.010872	14	C
A			
A	0.009595	14	O

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED

--------------------------- INTAKE=TU16 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 28

--------------------------- INTAKE=TU16 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00001613	0.16	0.6882
Error	26	0.00254787		
Corrected Total	27	0.00256400		

R-Square	C.V.	STP Mean
0.006292	46.70693	0.02119437

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00001613	0.16	0.6882

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00001613	0.16	0.6882

--------------------------- INTAKE=TU16 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.000098

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.021953	14	C
A			
A	0.020435	14	O

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED

& UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

--------------------------- INTAKE=TU17 -----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 28

--------------------------- INTAKE=TU17 -----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00000017	0.00	0.9641
Error	26	0.00207341		
Corrected Total	27	0.00207357		

R-Square	C.V.	STP Mean
0.000080	44.95043	0.01986652

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00000017	0.00	0.9641

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00000017	0.00	0.9641

--------------------------- INTAKE=TU17 -----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 0.00008

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.019943	14	O
A			
A	0.019790	14	C

ONE-WAY ANOVA ON STANDARDIZED SMOLT PASSAGE [(GUIDED

& UNGUIDED)/BYPASSED] AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

--------------------------- INTAKE=TU18 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 21

--------------------------- INTAKE=TU18 ----------------------------

General Linear Models Procedure

Dependent Variable: STP

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	0.00014345	0.35	0.5616
Error	19	0.00780991		
Corrected Total	20	0.00795336		

R-Square	C.V.	STP Mean
0.018037	63.03077	0.03216574

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	0.00014345	0.35	0.5616

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	0.00014345	0.35	0.5616

--------------------------- INTAKE=TU18 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: STP

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 19 MSE= 0.000411
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 10.47619

Number of Means 2
Critical F 4.3807497

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	0.034907	10	O
A			
A	0.029674	11	C

TWO-WAY ANOVA ON FGE AMONG INTAKES AND TREATMENTS

PH2 SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	8	TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18
CTREAT	2	C O

Number of observations in data set = 188

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	15	25082.4209644	2.36	0.0041
Error	172	121725.9101061		
Corrected Total	187	146808.3310705		

R-Square	C.V.	FGE Mean
0.170851	93.91434	28.3266607

Source	DF	Type I SS	F Value	Pr > F
INTAKE	7	20733.9214680	4.19	0.0003
CTREAT	1	1920.9578955	2.71	0.1013
INTAKE*CTREAT	7	2427.5416010	0.49	0.8410

Source	DF	Type III SS	F Value	Pr > F
INTAKE	7	21126.0441333	4.26	0.0002
CTREAT	1	915.7301858	1.29	0.2569
INTAKE*CTREAT	7	2427.5416010	0.49	0.8410

ONE-WAY ANOVA ON FGE
AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

--------------------------- INTAKE=TU11 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 5

--------------------------- INTAKE=TU11 ----------------------------

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	28.13225113	0.87	0.4193
Error	3	96.79985580		
Corrected Total	4	124.93210694		

R-Square	C.V.	FGE Mean
0.225180	55.69851	10.1984260

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	28.13225113	0.87	0.4193

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	28.13225113	0.87	0.4193

--------------------------- INTAKE=TU11 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 3 MSE= 32.26662
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 2.4

Number of Means 2
Critical F 10.127964

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	12.135	3	C
A			
A	7.293	2	O

ONE-WAY ANOVA ON FGE
AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

---------------------------- INTAKE=TU12 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 27

---------------------------- INTAKE=TU12 ----------------------------

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	1325.46361809	1.27	0.2702
Error	25	26059.85031686		
Corrected Total	26	27385.31393495		

R-Square	C.V.	FGE Mean
0.048401	77.07574	41.8888332

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	1325.46361809	1.27	0.2702

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	1325.46361809	1.27	0.2702

---------------------------- INTAKE=TU12 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 25 MSE= 1042.394
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.48148

Number of Means 2
Critical F 4.2416991

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	49.16	13	O
A			
A	35.14	14	C

ONE-WAY ANOVA ON FGE
AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

---------------------------- INTAKE=TU13 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 24

---------------------------- INTAKE=TU13 ----------------------------

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	939.84986529	0.70	0.4114
Error	22	29484.96744560		
Corrected Total	23	30424.81731089		

R-Square	C.V.	FGE Mean
0.030891	116.9760	31.2962430

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	939.84986529	0.70	0.4114

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	939.84986529	0.70	0.4114

---------------------------- INTAKE=TU13 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 22 MSE= 1340.226
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 11.91667

Number of Means 2
Critical F 4.3009495

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	38.10	11	O
A			
A	25.54	13	C

ONE-WAY ANOVA ON FGE
AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

--------------------------- INTAKE=TU14 ---------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 27

--------------------------- INTAKE=TU14 ---------------------------

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	961.70814964	0.90	0.3508
Error	25	26592.46737688		
Corrected Total	26	27554.17552653		

R-Square	C.V.	FGE Mean
0.034902	82.22140	39.6665529

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	961.70814964	0.90	0.3508

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	961.70814964	0.90	0.3508

--------------------------- INTAKE=TU14 ---------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 25 MSE= 1063.699
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 13.48148

Number of Means 2
Critical F 4.2416991

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	45.86	13	O
A			
A	33.92	14	C

ONE-WAY ANOVA ON FGE
AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

---------------------------- INTAKE=TU15 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 28

---------------------------- INTAKE=TU15 ----------------------------

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	163.55214576	0.27	0.6096
Error	26	15918.19449912		
Corrected Total	27	16081.74664488		

R-Square	C.V.	FGE Mean
0.010170	71.04504	34.8278331

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	163.55214576	0.27	0.6096

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	163.55214576	0.27	0.6096

---------------------------- INTAKE=TU15 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 612.2382

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	37.245	14	C
A			
A	32.411	14	O

ONE-WAY ANOVA ON FGE
AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

---------------------------- INTAKE=TU16 -----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 28

---------------------------- INTAKE=TU16 -----------------------------

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	922.35878352	2.23	0.1477
Error	26	10772.82990629		
Corrected Total	27	11695.18868981		

R-Square	C.V.	FGE Mean
0.078867	114.9811	17.7032063

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	922.35878352	2.23	0.1477

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	922.35878352	2.23	0.1477

---------------------------- INTAKE=TU16 -----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 414.3396

Number of Means	2
Critical F	4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	23.443	14	O
A			
A	11.964	14	C

ONE-WAY ANOVA ON FGE
AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

--------------------------- INTAKE=TU17 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 28

--------------------------- INTAKE=TU17 ----------------------------

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	3.65080460	0.01	0.9254
Error	26	10618.88527217		
Corrected Total	27	10622.53607678		

R-Square	C.V.	FGE Mean
0.000344	105.7744	19.1061090

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	3.65080460	0.01	0.9254

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	3.65080460	0.01	0.9254

--------------------------- INTAKE=TU17 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 26 MSE= 408.4187

Number of Means 2
Critical F 4.2252013

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	19.467	14	O
A			
A	18.745	14	C

ONE-WAY ANOVA ON FGE
AMONG SLUICE CHUTE TREATMENTS
PH2 SUMMER 96

--------------------------- INTAKE=TU18 ----------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
CTREAT	2	C O

Number of observations in by group = 21

--------------------------- INTAKE=TU18 ----------------------------

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	1	3.78387841	0.03	0.8579
Error	19	2181.91543334		
Corrected Total	20	2185.69931175		

R-Square	C.V.	FGE Mean
0.001731	71.33406	15.0226031

Source	DF	Type I SS	F Value	Pr > F
CTREAT	1	3.78387841	0.03	0.8579

Source	DF	Type III SS	F Value	Pr > F
CTREAT	1	3.78387841	0.03	0.8579

--------------------------- INTAKE=TU18 ----------------------------

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE

NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 19 MSE= 114.8377
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 10.47619

Number of Means 2
Critical F 4.3807497

Means with the same letter are not significantly different.

REGWF Grouping	Mean	N	TREAT
A	15.468	10	O
A			
A	14.618	11	C

ONE-WAY ANOVA ON FGE
AMONG INTAKES
PH2 SUMMER 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
INTAKE	8	TU11 TU12 TU13 TU14 TU15 TU16 TU17 TU18

Number of observations in data set = 188

General Linear Models Procedure

Dependent Variable: FGE

Source	DF	Sum of Squares	F Value	Pr > F
Model	7	20733.9214680	4.23	0.0002
Error	180	126074.4096025		
Corrected Total	187	146808.3310705		

R-Square	C.V.	FGE Mean
0.141231	93.42903	28.3266607

Source	DF	Type I SS	F Value	Pr > F
INTAKE	7	20733.9214680	4.23	0.0002
Source	DF	Type III SS	F Value	Pr > F
INTAKE	7	20733.9214680	4.23	0.0002

Ryan-Einot-Gabriel-Welsch Multiple F Test for variable: FGE
NOTE: This test controls the type I experimentwise error rate.

Alpha= 0.05 df= 180 MSE= 700.4134
WARNING: Cell sizes are not equal.
Harmonic Mean of cell sizes= 17.00309

Number of Means	2	3	4	5
Critical F	6.3306494	4.0490667	3.1796455	2.7121273

Number of Means	6	7	8
Critical F	2.416915	2.1492492	2.0607618

Means with the same letter are not significantly different.

REGWF Grouping			Mean	N	INTAKE
	A		41.889	27	TU12
	A				
B	A		39.667	27	TU14
B	A				
B	A	C	34.828	28	TU15
B	A	C			
B	A	C	31.296	24	TU13
B	A	C			
B	A	C	19.106	28	TU17
B		C			
B		C	17.703	28	TU16
		C			
		C	15.023	21	TU18
		C			
		C	10.198	5	TU11

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13.ABSTRACT ***(Maximum 200 words)***

This technical report describes results of studies conducted by the U.S. Army Engineer District, Portland, and the U.S. Army Engineer Waterways Experiment Station to resolve critical uncertainties in the implementation of surface-collector technologies and the estimation of fish passage efficiency (FPE) for juvenile salmon at the Bonneville Project. The goals of this study were to (a) provide biological information necessary to facilitate the design and placement of a surface-collector prototype and (b) make progress toward the estimation of FPE for the entire project.

Objectives were as follows:

a. Use mobile hydroacoustics to measure the vertical and horizontal distribution of salmon smolts in forebay areas of both powerhouses and to characterize the day and night variation in distributions in spring and summer.

b. Estimate smolt passage into two turbines and into the center sluice gate above each turbine, as well as the FPE ratio for paired sluiceway/turbine openings under two test conditions (blocked versus unblocked trash racks and open versus closed sluice gates) in spring and summer at Powerhouse 1.

(Continued)

14.SUBJECT TERMS

Bonneville Dam	Fish passage efficiency	Mobile hydroacoustics
Fish guidance efficiency	Fixed-aspect hydroacoustics	Salmonid smolts
Fish passage	Juvenile salmon	

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c. Evaluate smolt swimming direction in the area immediately upstream of two test units at Powerhouse 1, particularly at the zone of separation between flows entering turbines and flows entering sluice gates.

d. Estimate guided and unguided smolt passage into eight turbine intakes of Powerhouse 2 and identify effects of an open or closed sluice chute on the fish guidance efficiency of adjacent turbine units. The enclosed Summary presents highlights of study results, discussions, and conclusions.